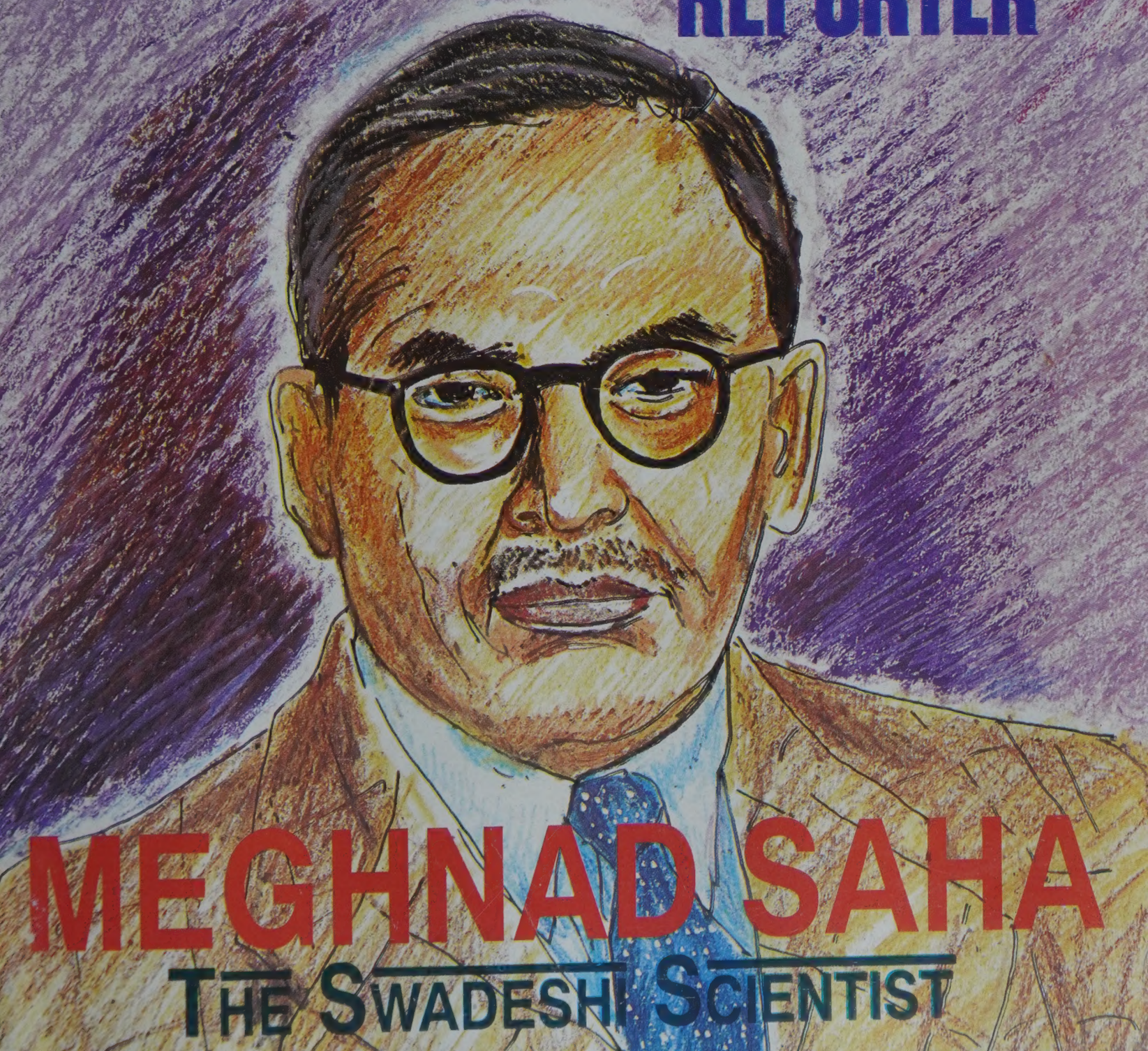
OCTOBER 1993
RUPEES 5.00

INDIA'S SPACE SAGA

SCIENCE REPORTER

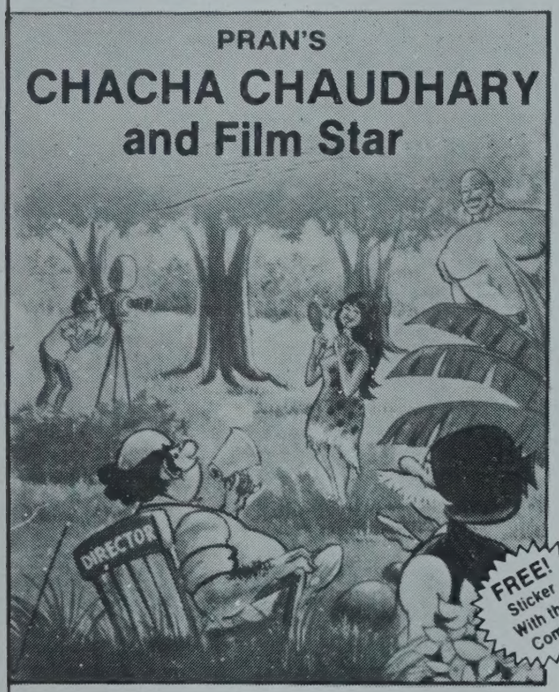


MEGHNAD SAHA

THE SWADESHI SCIENTIST

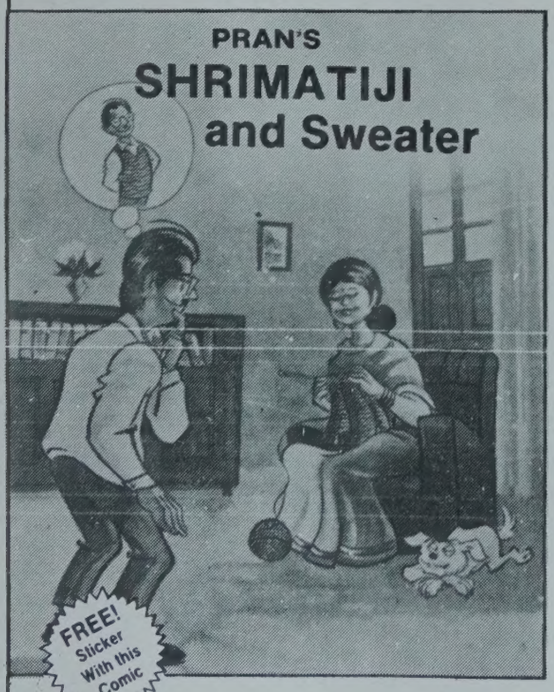
Chacha Chaudhary, the man whose Brain works faster than computer and Sabu, the most robust man on earth,new comic

CHACHA CHAUDHARY and Film Star



A baquet of humorous and fralicsome encounters of Shrimatiji and her husband Kishore. A social entertaining comic for whole family new comic

SHRIMATIJI and Sweater



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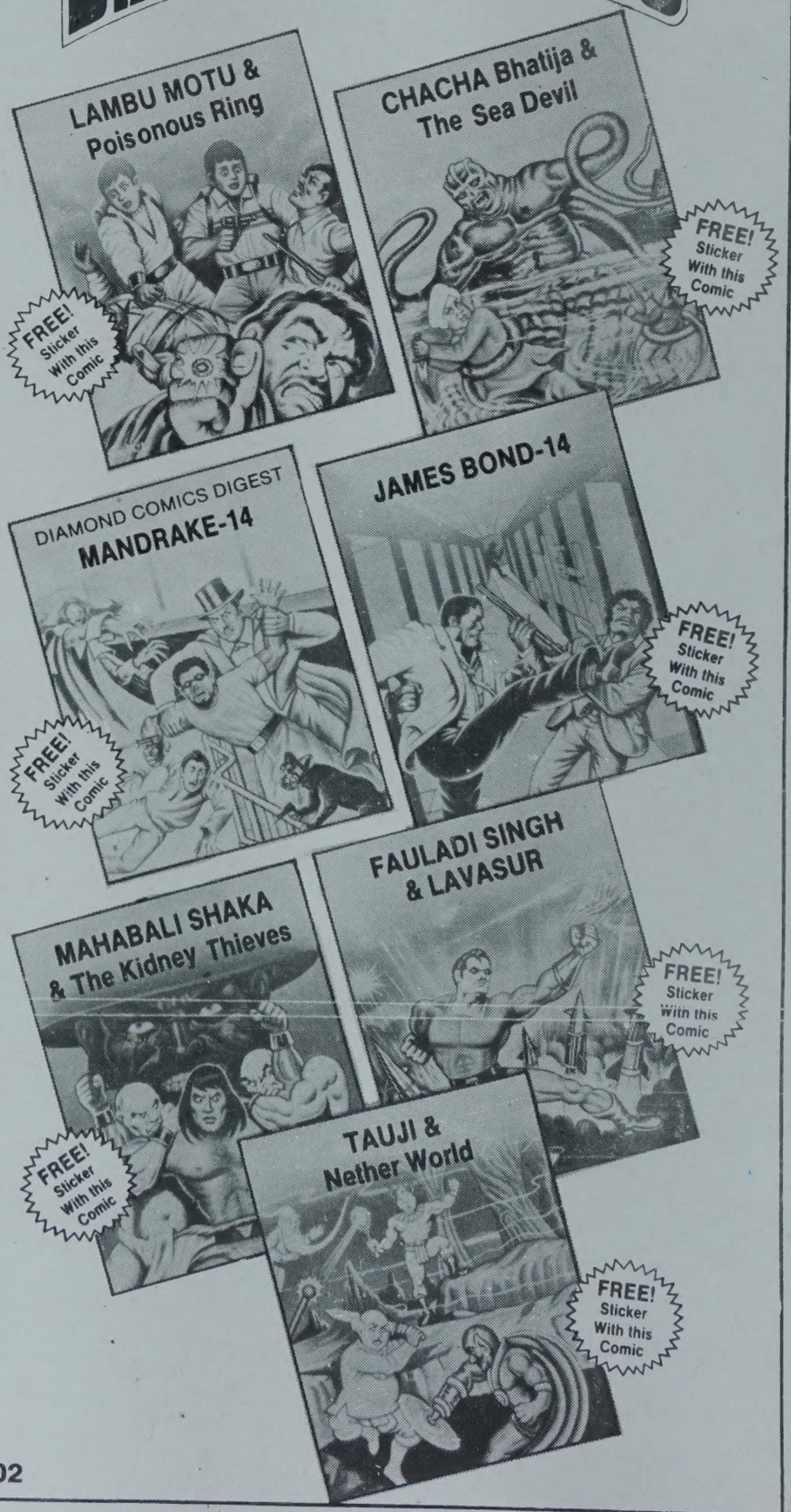

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COVER STORY

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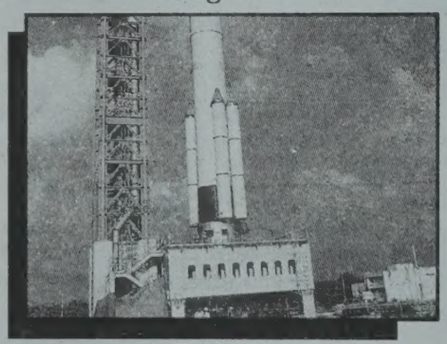
INDIA CAN DO IT



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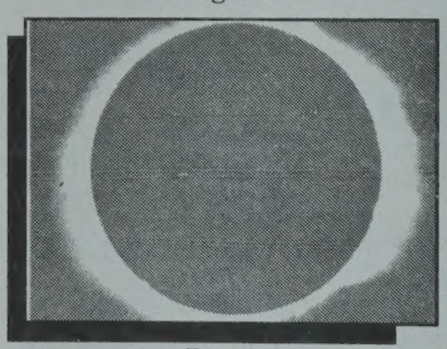

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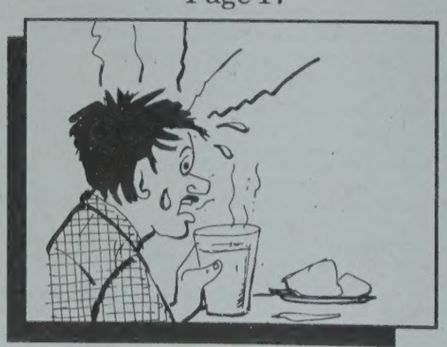

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DEPARTMENTS

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Vol. 30, No. 10, OCTOBER 1993

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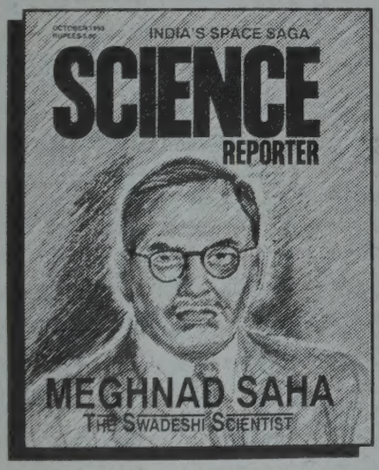

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Text Layout: **K. B. Dhingra**

Learning by Failure

NOTHING succeeds like success. That is an old saying. But despite best efforts, success at times can be highly elusive as it was with the recent launch of the Polar Satellite Launch Vehicle. The mission failed, according to ISRO sources, because of an error in the third stage of the rocket. It was a great disappointment for India's space scientists who had pinned high hopes on this launch. However, going by the experience of the other space powers this failure should not be a cause of despair. Some of the early US and Soviet space missions had quite high failure rates.

Despite the apparent failure of the mission to put a remote sensing satellite into a polar orbit, however, the first flight of the PSLV is said to have accomplished a great deal. The launch of the 275 tonne, four-stage launch vehicle was perfect, demonstrating the soundness of the 129-tonne solid fuel first stage, said to be the third largest solid booster in the world. It used indigenously produced fuel and oxidizer. The six solid-fuelled strap-on motors also performed flawlessly and separated as planned. The flight was also a demonstration of the successful performance of the indigenously developed liquid propellant engine ***Vikas****, tried out for the first time. In a nutshell, the flight validated most of the systems which will be used in the more powerful Geostationary Satellite Launch Vehicle (GSLV), which is to become the main workhorse of ISRO in the years to come.*

There is no denying the fact that in high-tech areas, even when pursued by the most technologically advanced nations, success cannot always be taken for granted. The failure of ***Challenger*** *and* ***Mars Observer*** *missions are still fresh in our minds. But failures have invariably made way for better designs and later successes. India's own ASLV is a glowing example of this process. Therefore, last month's failure which has been aptly described by the ISRO Chairman as 'a mixed bag of successes' should instill a new sense of commitment among India's space scientists to make the next flight of the PSLV a spectacular success. Can there be a better way of learning than from our past failures ?*

Reactions

Supercomputers

The article **Supercomputing: Indian style** (*SR*, August 1993) by Biman Basu was very informative. I think with such articles SR will make people well-informed of our achievements. Thanks to all staff of *Science Reporter*.

Anup Kumar Ghosh
Chas (Bihar)

II

The front cover of August 93 made *SR* look a magazine of the 21st century. While going through the magazine I realized some where in the future our INDIA will be ahead of all other countries, developing ones at least, in the field of information and technology.

Kumar Nishant
Patna-1 (Bihar)

Break Through Indeed!

The cover story **Supercomputing : Indian Style** (*SR*, August, 1993) was exclusive indeed. Through this article Biman Basu has enlightened us with the latest advancement and achievements of Indian labs particularly in the field of supercomputers. We must appreciate Indian scientists for their efforts in placing India in the list of the very few countries which have developed supercomputers.

I would like to share some more points with your readers. The parallel supercomputers being developed in the Europe and U.S. have as many as 65,536 processors in parallel with unmatched speeds. Indian scientists at the Pune-based C-DAC are also keeping pace with these developments trying to achieve greater speeds, of the order of trillions of operation per second. If we take the application of these parallel computers, India is at the leading edge. However, I am afraid advertising too much about India's achievements in this field may even have negative consequences. Instead, India should boost its software exports which is one of the largest earner of foreign exchange in the world market.

Any way let us hope that Indian scientists would strengthen their position in the world market in this field inspite of all the hurdles (like funds) facing them.

R. Raveendranath
Bellary (Karnataka)

Cryogenic tech-nology

You have mentioned in your editorial 'Blessing In Disguise' (*SR*, August 1993) that we should launch geostationary satellites from our own know-how. The cryogenic deal with Russia is almost off as the erstwhile superpower has abjectly caved in to the pressure tactics of America. The reason for America's arm-twisting may be either commercial or it simply does not want another country to acquire proficiency in a sensitive field.

You have rightly exhorted ISRO to develop cryogenic technology and turn the situation to their advantage. Defence analysts believe that if and when India launches a geostationary satellite, from its own resources, then it will be able to launch an ICBM (8000-12,000 km) within 5 years. Though it is admitted that our intentions are not to strike at such deep targets, nevertheless, it will certainly discourage potential adverseries in the region.

S.K. Gurtu
Delhi

Bravo, India!

Time and again, whether it be the construction of the largest cable-stayed bridge or the indigenous cryogenic engine or the latest supercomputers, Indian technocracts have proved their efficiency. But, astonishingly, the main impetus behind all this technological progress, is a denial of foreign assistance, which acted as a stimulant for Indian technologists.

Now, it is high time for Indian technologists to think of a self-styled stimulatant. Who knows, there may be a ban on the supply of stimulants too! I can suggest a possible stimulant, it is nothing but *sincere nationalism*.

Sujay Banerjee
Berhampur (W.B)

Test Tube Babies

Please convey my hearty congratulations to Ms. Sukanya Dutta for her article **In search of life** (*SR*, August 1993). It was exceedingly informative and interesting. I agree that despite population explosion, thousands of childless couples earnestly desire a child. Due to lack of knowledge, most people traditionally attribute infertility to bad luck and the wrath of the Lord. The available technology is a ray of hope for such families and will give succour to the lives of thousands of grief-stricken women.

Dr. Dutta has successfully discussed the various reasons of infertility and various successful solutions. She has also described the religious, social and moral impacts these technologies may have. Such articles need to be conveyed to public especially such persons.

S. Shaida A. Andrabi
Aligarh (U.P.)

Reactions

Fascinating

The article **Return to Mars** (*SR*, August 1993) by Biman Basu was fascinating and informative. Is it possible to make a lifeless, red planet green. Thanks a lot for the attempt to bring out information about the red planet, Mars. I request you to give such information about other planets also.

Ashwani Kumar Sahoo
Bhubaneswar (Orissa)

On The Vigil

Many a thanks for publishing the article **On the Vigil** (*SR*, July 1993). The information and facts were really superb. If the pace of the progress is not checked by the population explosion, India will surely become a world-power one day. Again a lot many thanks for giving the valuable information about octopuses. Wishing the *SR* will be more informative in the next issue.

Shakeb Danish Gayanvi
Bihar

Better Than Brain-Drain

My reaction is in respect of your Editorial **Pride and Prejudice** (*SR*, July 1993) where you have commented upon the need to divert professional talent trained at huge public expense to non-professional jobs.

It is better for these professionally trained students to join IAS Civil Service rather than losing them through the brain-drain to American Universitiesw. A study conducted in IIT, Bombay, over a decade ago, had indicated that out of 100 engineering graduates who go abroad, on an average only 40 return back (That means 60% of the top students are lost to the nation every year). Actually the loss was much greater in certain disciplines like electrical, mechanical, Computer and Chemical Engineering (about 500-705), whereas in Civil and Metallurgical engineering the loss was about 20-40%. Once the student settles abroad, the Rs 6-7 lakhs spent on him (according to your figures) is lost to the nation foever.

Hence our outcry at migration of engineering talent to IAS must be tempered with the realities of the situation. I would say that the engineering students who join IAS have atleast attachment to this country and serve the nation.

P.D. Sunawala
Bombay (Maharashtra)

II

This refers to your editorial in *Science Reporter*, July 1993 regarding engineers capping top positions in Civil Service Exam 1992.

The argument that it is a wastage of talent and money as Government spends six to seven lakh Rupees on an engineering student seems one-sided. If we look at the educational background of the majority who ultimately make it to the Civil Services, we find that a majority of them are post-graduates. We all know that the post-graduate education is equally subsidised by the government.

If we explore the background why engineers are attracted towards Civil Services, we find the reasons to be the lack of development of private sector to satisfy the career needs of an engineering student and the churning out of herds of engineers every year by our institutions when there is a large scale unemployment. But the most important reason is the plight of engineering service vis-a-vis Civil Services. The career development, monetary benefits and social recognition of the two service just cannot be compared.

As you had pointed out it is indeed vocation that needs attention because an engineer or non-engineer is useful to this country in any capacity he works so long as he is satisfied with his career and does not leave this country.

Anuj Kanwar
Delhi

Brains Trust

I got confused by the answer given to the question "why does a sprinter — standing position" in Brains Trust (*SR*,Reporter, August 1993). This is because as far as I know there is no horizontal component of weight. At every point of the body — whatever be its configuration — the weight acts vertically. The horizontal component of the reaction of the force produced by the hands against the ground produces the extra acceleration.

Rajkumar Roychoudhury
Calcutta (W.B.)

Yes, you are right. There was an inadvertent error in the answer.

Editor

BRAINSTRUST COUPON OCTOBER 1993

Please send only one question on post-card to the address below.

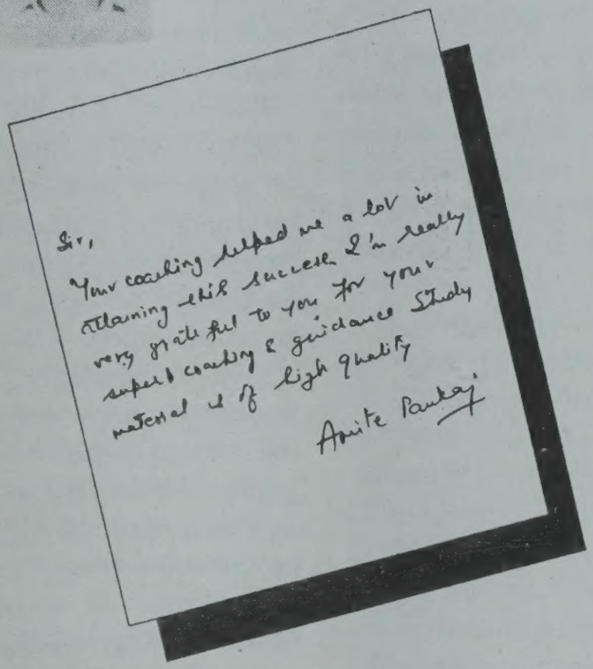
Editor
Science Reporter
(Brains Trust October 93)
Dr. K. S. Krishnan Marg
New Delhi-110 012

The tradition continues ...

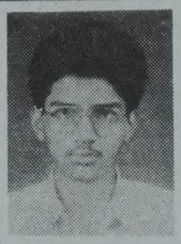
C.B.S.E. topper '92 writes ...

Pankaj Amite

1st in **CBSE'92** & **PMT** (Haryana)



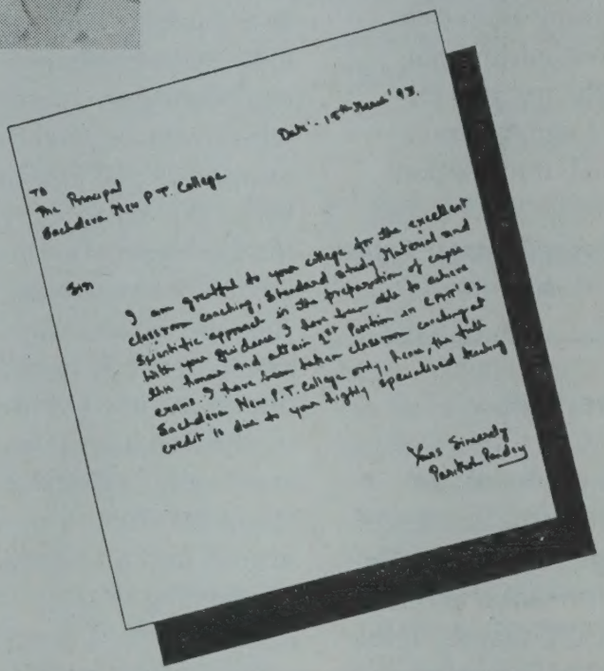
Sir,
Your coaching helped me a lot in attaining this success. I'm really very grateful to you for your superb coaching & guidance. Study material is of high quality.
Amite Pankaj



C.P.M.T. topper'92 writes ...

Paritosh Pandey

1st in **CPMT'92** (General Category)



Date: 15th June '92.

To
The Principal
Sachdeva New P.T. College

Sir,

I am grateful to your college for the excellent classroom coaching, Standard study Material and Systematic approach in the preparation of exams. With your guidance I have been able to achieve this honour and attain 1st Position in CPMT'92 exams. I have been taking classroom coaching at Sachdeva New P.T. College only, hence, the full credit is due to your highly specialised teaching.

Yours Sincerely
Paritosh Pandey

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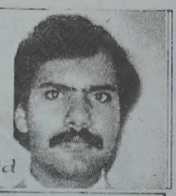
How to Use More Mind Power for success in exams and competitions

(Most people use only 10%)



by Raj Bapna

Remember more in less time. Improve your concentration. Read faster. Get more marks in exams. Develop self-confidence. Avoid mistakes.

My name is Raj Bapna. I want to tell you how to study and how to use your mind power to get success in competitions. This is from my new 224-page *surprisingly powerful* course "Raj Bapna's Mind Power Study Techniques".

Why Use Only 10% Mind Power ?

Scientists have recently found that most people *use* only 10% of their *mind power*. So, upto 90% of the mind power remains hidden and unused.

And Indian yogis have always known this.

If you *learn* to *use* more *mind power* to study, you can remember more in less time. So, your chances of success in competitions can greatly increase.

My proven, result-oriented *course* will *help you* in everything you want to *study*: **Chemistry, English, History**, etc. and for **IAS, PMT, IIT, Board Exams, PO, Bank, UPSC, SSC**, etc. My course will help you to make the best use of your hard work and your coaching/studying for success.

But... Not for Everyone

This course is not for those persons who want to get success by magic. It is also not for those persons who want to get success without work.

But, it is for that sincere and ambitious person who studies average or more and very seriously wants to *get success*.

Surprising But True

You have been learning many subjects in schools or colleges for 10, 12, or 15 years. It is surprising that, even for one hour, they do not teach you how to use your mind power and how to study for success.

What Will You Learn

You will improve in the following 9 ways:

1. Good increase in your memory and concentration **2**. Small to moderate improvement in your intelligence **3**. You will not be required to study for more hours, but your ability to study longer without getting tired or feeling sleepy will increase **4**. Your effectiveness to read and learn will increase greatly **5**. You will experience that you are capable of achieving much more than you currently do (yes, even if you are a topper) **6**. Set realistically high aims/goals and take you step by step on the road to achieving them **7**. Improve your writing, spelling, interview skills **8** Learn exam secrets to get more marks for what you know **9**. Avoid serious mistakes that can lead to failure.

Read Faster to Save Time

Everyone can learn to read and understand 300, or 500 or more words per minute. But, many of us read only about 100 words per minute.

You will learn my easy Finger Technique in 30 minutes that will prove to you that you can double your reading speed.

The best use of faster reading is not to learn new things for the first time, but to revise again and again quickly so that you can remember more in less time (Why? See Memory Secrets in next column)

PROOF of Reader's Success

- I am very happy to inform you that my son Ravi Anand increased his reading speed from 228 to surprisingly high 1818 words per minute. Thank you for your excellent course." — *Dr M L Singh, MBBS, MS, Eye Surgeon, Bihar.*
- Unbelievably, I improved my reading speed from 75 to 200 words per minute. My son (class 4) improved his memory. He also improved his reading speed from 45 to 100. — *Prof M Bhatnagar, PhD, Formerly in USA*
- Excellent course ... it has changed my life style. Increased my reading from 86 to 303 words per minutes in 5 days and strengthened my dream of success in AIIMS, All India etc. — *Dr Ratnakar Sahoo, SCB Medical College, Orissa*
- It is lucid, simple, powerful. — *Prof J Nagrath, Deputy Director, BITS Pilani*
- Increased my reading from 100 to 350 in 2 days. — *Shashi K Singh, Computer Engineer, Dehradun (U P)*
- I topped the DAV College. Increased speed from 303 to 1000 words. — *Sanjeev Dixit, Panchkula, Haryana*
- Stimulating... my wife/son also reading it with delight— *M Sebastian, Principal, Navodaya Vidyalaya*

Can You Answer These 6 Question?

- For better memory, should you study early in morning or late in night?
- For better memory, should you read faster or slower?
- Do examiners give more marks if you write more and fill more pages?
- Which vitamins can help your brain function better and improve your IQ?
- Should you study continuously or take rest?
- Why does eating before an exam reduces IQ?

Memory Secrets

The brain has two memory stores: short-term and long-term. Whatever you see, hear, or feel is processed by the brain. The irrelevant information is removed immediately. The remaining information goes into short-term memory. Whatever we revise again and again goes into long-term memory.

Research shows that without revision, in 24 hours we forget 82%. So, we remember only 18%.

As time passes without revision, we remember less and less. After one month we remember about 5%. Most people attend classes or make notes, but they do not revise enough, so they do not remember as much as they can, and their hard work is wasted.

My course will teach you a systematic technique to revise and remember more in less time. You can learn this powerful technique in just 30 minutes.

You will learn more secrets from my course.

My Unique Course

My unique course combines the 5000 year old techniques of India with the latest scientific discoveries in brain research, nutrition, psychology, and music in America and other countries.

Newspapers Say This Course Is ...

- Simple, effective, practical techniques to improve overall intelligence and mind power. Even average student can easily understand. — *Times of India*
- Powerful, practical, easy. It will help all students, bank officials and others appearing for test, exams and interviews. — *Indian Banks' Asso. Bulletin*
- It teaches how to succeed in exams and life-struggle. — *Malayala Manorama*

13 Powerful Chapters

Chapter 1. Learn two mind power study techniques in one hour and quickly improve your study efficiency **Chapter 2**. Exam secrets for getting more marks :- Do not eat just before an exam. How do examiners correct answer papers, and how to use this knowledge to *get more marks*. Mega-vitamins can *increase your intelligence* temporarily during exam-days. For these 2 types of questions, you can even fool the examiner and get more marks. 4 more topics **Chapter 3**. Interview techniques for self-confidence and success :- 4 topics **Chapter 4**. Some major mistakes in exam-days and how to avoid them :- 3 topics **Chapter 6**. How to improve your memory in a surprisingly easy way

This course is never sold in any shops

Chapter 7. Mind maps: a new scientific way to take memorable notes:- Memory key words and creative key words. The best way to take notes. 7 more topics. **Chapter 8**. Some techniques for improving memory, concentration, and intelligence :- Take these vitamins to *improve* the functioning of your brain and your body. How to sleep well. Meditation: an ancient technique for more brain power. *Increase your intelligence* by Image Streaming. 5 more topics

Chapter 9. Advanced memory techniques to remember long sequences, spellings, and complicated things :- 5 topics **Chapter 10**. How to use your time in the classroom for success :- 8 topics

Chapter 11. Program yourself for success by using the power of beliefs, imagination, and Neuro Linguistic Programming :- Anchor yourself for success while watching TV or films. Using music and relaxation for mind programming. Changing beliefs and habits. 5 more topics **Chapter 12**. New research in brain science shows that you are more capable than you think

Chapter 13. 32 Important questions & answers

Author's BIO-DATA

- The maximum the USA companies paid for me in a single month was $18,002 (over Rs 5 lakhs in one month). At peak of success, I left USA to return to India to teach my mind power study techniques. Now I spend my full time in research in India.
- B E, BITS Pilani. M Tech, IIT Kharagpur. NTS scholar. Rank 5 in Raj High School Board.
- World-famous author. Published 3 books in USA including my best selling book " Tricks of MS-DOS Masters", 721 pages, $27.95.
- Increased my reading speed from 72 words to as fast as 1037 words per minute.
- My first job as an engineer paid only Rs 1000 per MONTH. Finally, I earned $50 (Rs 1500) per HOUR in USA as a computer expert.
- Expert in computers, mind power, study techniques. Spent $1300 (about Rs 40,000) for 2 seminars in USA to learn the mind power techniques called Neuro-Linguistic Programming. Was a member of Society for Accelerated Learning & Teaching, USA.
- Learnt French, Sanskrit, Karate, Breaking wooden board by hand, many Meditations, etc.

I Lost A Big Chance. But You...

I wanted to take the best course for IIT entrance. I was not *sure* if the *course* would *really help* me. So, I did not *order quickly*. After waiting for 3 months, I *ordered* the *course*. The course was good and it helped me get rank 1102.

I lost a big chance to join BTech in IIT because I did not *order quickly* and waited for 3 months.

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BOOK 10 • Sports
BOOK 11 • Fishes
BOOK 12 • Sea Animals
BOOK 13 • Insects & Reptiles
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Cover Story

Meghnad Saha

Scientist who Understood India

Saha was not only a great scientist but also a planner who had a great vision for the future of the country he loved says *V. G. KULKARNI*

MEGHNAD Saha, (born, October 6, 1893 - died, February 16, 1956), was not born with a silver spoon in his mouth. Fifth child in a family of eight children, young Meghnad had only primary education in Seoratali, the village in Dacca district where he was born. Even for his middle school education Saha had to draw upon the generosity of Dr. A.K. Das, a medical practitioner in a neighbouring village more than 10 kilometres away. However, Meghnad Saha stood first in the middle school examination in Dacca district and was awarded a government scholarship which enabled him to attend high school. Saha never looked back thereafter, winning scholarships at every step to complete all echelons of formal education.

Perhaps he was a precocious student excelling in science, mathematics and also in languages. However, what distinguishes Meghnad Saha from the "merit holders" of his day is his exceptionally sensitive perception of the problems of his land and his desire to apply his knowledge to solving them. Floods and famines, poverty and lack of development, and utter mismanagement of everything seem to have made a deep impression on the young Saha as seen from his later writings and activities.

SAHA'S scientific career took shape in a truly remarkable era in the history of science. The turn of the century witnessed the entire human thought rocked in an unprecedented way. Successes with Newtonian mechanics and the insights provided by Maxwell's theory of electromagnetism had created an impression that all that was to be known was essentially discovered and what remained to be done was dotting the 'i's and crossing the 't's. Scientists were rudely shocked out of their complacency by the discoveries of X-rays and the electron. The atom that was once indivisible, now looked more like a solar system, with its structure and its nucleus posing new challenges. The Newtonian mechanics that could predict the behaviour of the system if only the initial conditions were stipulated had to yield, reluctantly but surely, to the probabilistic interpretations of the quantum theory. To surmount all this there was the great Einstein with his theory of relativity. It was an era in which almost the entire human thought seemed to have been trapped in a turbulence. It was also pregnant with new challenges and rich promises beckoning the gifted.

How fortunate that India produced men equal to this challenge. The careers of C.V. Raman, Meghnad Saha, Satyendranath Bose and P.C. Mahalanobis, to name a few, who made important contributions to science to put India on the scientific map of the world, all spanned this era. It was in this period that the young Meghnad Saha joined the Presidency College at Calcutta in 1911, graduating with an M.Sc. degree in 1915. Here he was in excellent company; his contemporaries being S.N. Bose (author of the Bose-Einstein statistics), R.N. Sen, J.N. Mukherjee, J.C. Ghosh, P.C. Mahalanobis, and the famous chemist N.R. Dhar. His teachers were, Jagdish Chandra Bose, Acharya Prafulla Chandra Ray, D.N. Mullik and C.E. Cullis. Both in the B.Sc and the M.Sc. examinations Saha stood second at the university, S.N. Bose being the first. Even amongst such luminaries, Meghnad Saha distinguishes himself not only by his contributions to pure research but also by his intense desire for applying his knowledge and wisdom for national development.

"The name Meghnad Saha is associated with the theory of thermal ionization and its application to the interpretation of stellar spectra in terms of physical; conditions prevailing in the stellar atmosphere." This biographical statement highlights Saha`s contribution to physics. However, the importance of this achievement can be appreciated only when one understands the socio-political ethos of that era. India was reeling under the full weight of the colonial yoke of the British emnpire on which the sun never set. Opportunities for higher education were too few, with the education system being designed

for creating an administrative cadre for the British, and opportunities for research were even fewer. More importantly, Indian scientists found themselves outside the mainstream of scientific communications. They had to rely only on published information received rather late, and were denied the advantages of peer group interaction on which western science thrived so critically. Consequently, research activities that managed to survive in Indian Universities were hardly equipped to deal with the frontiers. It is remarkable that a boy born in a remote village in Dacca district should overcome poverty, distinguish himself at the university and literaly aim at the stars.

Saha was sensitive to the developments on the frontiers of science. With S.N. Bose he produced the first English translation of the original (German) papers of Einstein and Minkowaski. The prediction of the general theory of relativity that light rays passing close to a massive stellar object like the sun would bend towards it, was experimentally confirmed in the total solar eclipse in May 1919. It was news of considerable importance on which Saha was invited to write an article for the layman in *The Statesman*. By this time Saha was deeply interested in spectra of stars which he studied in considerable depth to produce his now famous theory of Thermal Ionization.

The structure of the atom with electrons orbiting around a heavy nucleus had been proposed by Neils Bohr. Saha quickly saw its relevance for understanding stellar spectra. At very high temperatures atoms in a gas will collide with each other violently and will be stripped of the outermost electrons, a process known as ionization. Hotter the body, greater is the chance of ionisation. Saha also considered the reverse process in which an ionized atom might pass close to a free electron and capture it to become a neutral atom. The chance of such a recombination in a gas increases with the pressure. also the probability of ionization depends on the ionization potential or the energy needed to knock out the electron. While all these facts were known, it was the genius of Saha that estimated correctly the role of temperature and pressure and recognised the need to use accurate values of the ionization potentials of various atoms. He proposed the now famous elegant mathematical equation :

$$\log \frac{x^2}{1-x^2} P = -\frac{U}{2.3\,RT} + \left(\frac{5}{2}\right) \log T - 6.5.$$

In this equation, P is the pressure expressed in atmosphere, x is the degree of ionization, R is the gas constant and T the temperature. It may be pointed out that earlier theories that did not take into account all these parameters could not explain why outer parts of the solar atmosphere show a higher degree of ionization indicating higher temperatures. Saha's theory explained that low pressures at those heights slowed down the recombination rates yielding to higher ionization than parts on the surface where temperatures were hotter but so were the pressures and their cumulative effect yielded lower ionization. His theory has stood the test of time and has successfully interpreted all known experimental data besides making verifiable predictions.

BESIDES his contribution to physics, Saha must rank as an exceptionally gifted teacher. During his stay at the university of Allahabad (1923-38), he built one of the finest departments of physics shouldering full responsibility to teach frontier areas like, spectroscopy, wireless and X-rays. His lectures were famous not only for the mastery of exposition but also for the large number of carefully designed demonstrations of experiment. Saha, a born experimentalist, quoted frequently from *'Rasendra Chintamani'* the 9th century Sanskrit work, "They are alone to be regarded as real teachers who can show by experiments what they teach. They are the deserving pupils who having learnt from their teachers can actually perform them and improve upon them. The rest are mere stage actors." It is not surprising that his teaching inspired student like, B.N. Srivastava, A.N. Tandon, D.S. Kothari, R.C. Majumdar, P.K. Kichlu and N.K. Sur who rose to eminence in independent India. Later, when he moved to

M. N. Saha (standing first from left) with P.C. Ray (Centre of the photo)

(Continued on page 24)

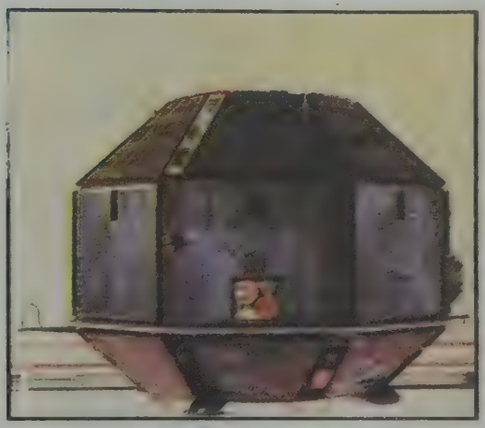
India Can Do It

Undeterred by constraints of resources and technology, India has succeeded in finding a place among the space venturing nations, says *BIMAN BASU*

A PLACE IN SPACE

India Can Do It

HOW do you describe the feat of designing and fabricating a dozen satellites, launching three of them using indigenous rockets, all in a span of less than three decades ? Nothing spectacular by world standards, may be. But, for a developing country like India, burdened with severe constraints of technology and resources, this is no mean achievement. The success of INSAT-2A and INSAT-2B in particular has amply demonstrated the capacity of Indian space scientists in the high-tech area of designing and building advanced geostationary satellites. Today the INSATs are the only satellites over the Indian Ocean region that keep a constant vigil over the region's changing weather system. If the launch of the Polar Satellite Launch Vehicle (PSLV) goes through as planned, India will have earned the rare distinction of having the capability of not only designing and fabricating but also launching its own 1000-kg class satellite. The PSLV, which is a precursor of the more powerful Geostationery Satellite Launch Vehicle (GSLV), is designed to put a remote sensing satellite of the IRS-class into a 900-km polar orbit.



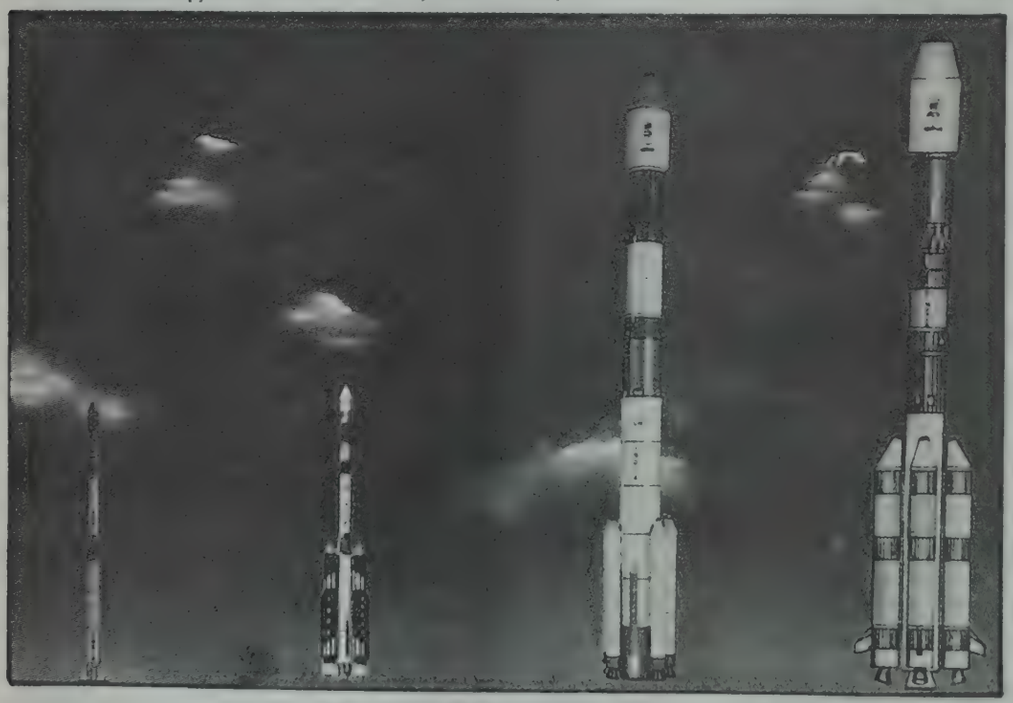
ARYABHATTA started it all

IRS - 1A image showing glacier features. A - accumulation area; AB - ablation area and I-ice divide

INDIA'S space programme started on a modest scale in November 1963 with the launching of a small American Nike-Apache rocket from the newly-built launching pad at Thumba. At the helm of affairs overseeing this token achievement was Dr. Vikram Sarabhai, Chairman of the estwhile Indian National Committee for Space Redsearch. Dr. Sarabhai was convinced that the newly emerging space technology offered solution to many of the nagging problems that plagued a vast and economically backward country like India. "It is not the question of whether India can afford to invest in space research", he would say, "but whether she can afford not to invest in it." Today, the Indian space Research Organisation (ISRO) under the Department of Space through its many centres plays the pivotal role in the planning and execution of national space activities which include development, launch and operation of space systems and their applications.

India Can Do It

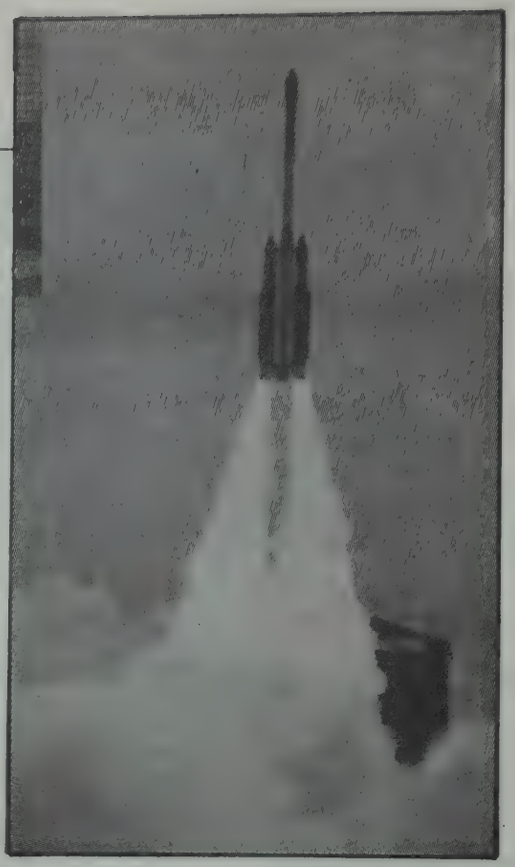
One significant feature of the Indian space programme has been the emphasis on reaping the benefits of space technology in the shortest possible time. Consequently ISRO took up development of satellite technology even before it could attain satellite launch capability. The first Indian-built satellite, *Aryabhatta*, was put into orbit by a Soviet launch vehicle in 1975. More satellites followed. Except three of them all were launched by foreign launch vehicles, but they provided valuable experience to Indian space scientists in satellite technology. The success of India's two remote sensing satellites IRS-1A, and IRS-1B, and of the two satellites of the INSAT-2 series is a good demonstration of this experience.



The club of ISRO launch vehicles

Utilisation of satellite technology is another area in which India took an early lead. The first satellite-based television relay experiment called the Satellite Instructional Television Experiment (SITE) in 1975 for the first time demonstrated the enormous potential of satellite in mass education and information dissemination. In 1977, a two-year Satellite Telecommunication Experiment Project (STEP) further demonstrated the possibilities of satellite-based telecom systems. Together these two experimental projects prepared the ground for the INSAT system.

A major landmark in Indian satellite development programme was reached in 1981 when the first indigenously built geostationary satellite, APPLE (Ariane Passenger Payload Experiment) was successfully launched by an Ariane rocket of the European Space Agency. APPLE was used in several communication experiments including relay of TV programmes, and radio networking. It provided valuable experience to Indian space scientists in building and operating geostationary communication satellites. But APPLE was only an experimental satellite. The first geostationery satellite for exclusive domestic use was INSAT-1B which became operational in 1983.



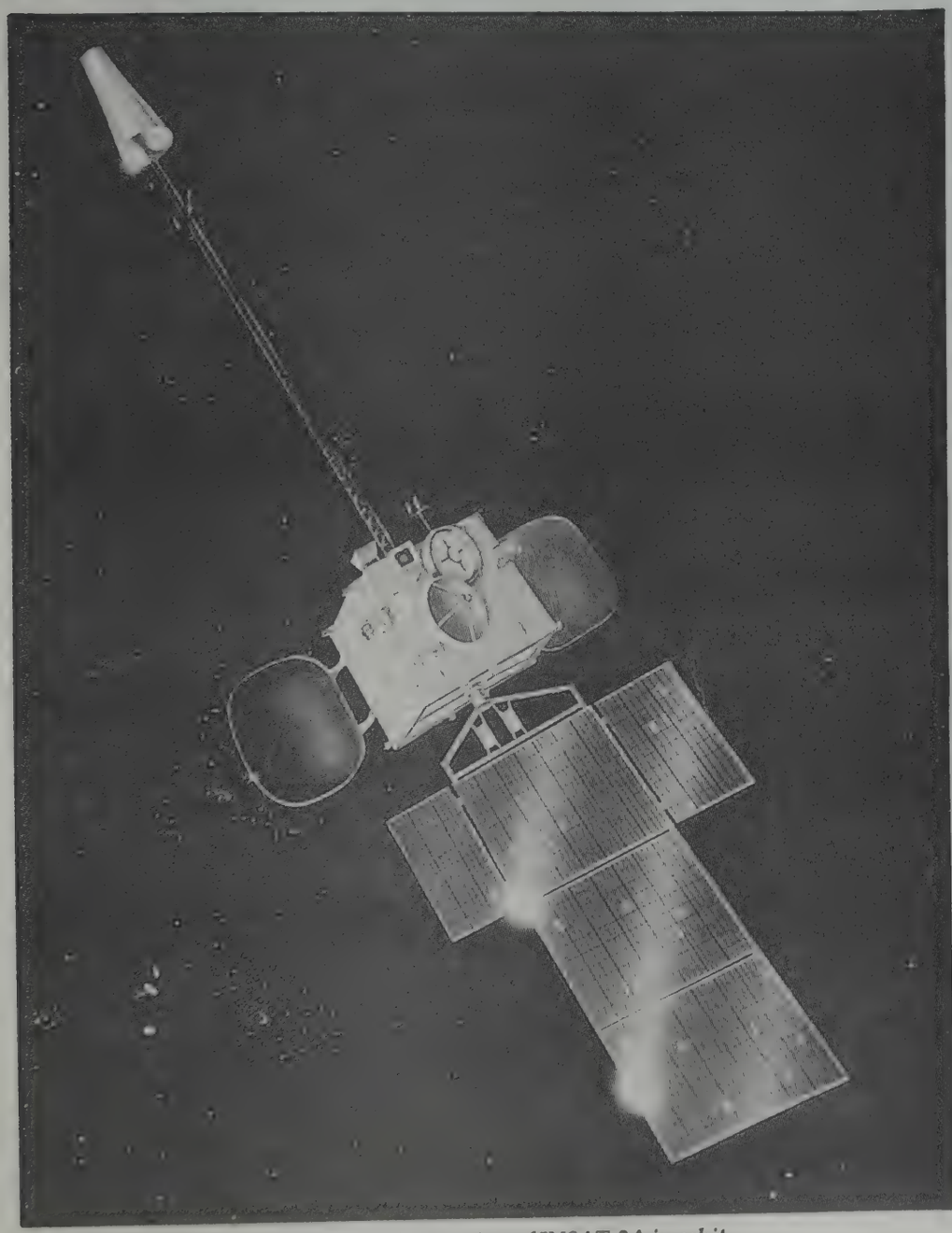
ASLV takes off

As far as satellites go, the INSAT is a unique concept. A brain child of Indian space scientists, who wanted to make the most of the available resources and technology, each satellite was conceived as three-in-one package capable of providing simultaneously reliable long distance telecom services, round-theclock earth observation and data relay facility, and countrywide networking of All India Radio and Doordarshan centres. In order to get the INSAT system in operation before the 1982 Asiad in New Delhi, and to gain time for the indigenous fabrication of satellites for the system, contract for the fabrication of all the satellites of the first generation, namely INSAT-1A, INSAT-1B, INSAT-1C and INSAT-1D, were awarded to the US firm Ford Aerospace. Only two of them — INSAT-1B and INSAT-1D — functioned well, the other two had to be abandoned in space due to a series of technical glitches soon after launch. The first of the indigenously-built satellites of second generation INSATs, INSAT-2A, was launched in July last year and INSAT-2B this year. Both have been performing flawlessly. This has given new confidence to Indian space scientists in satellite building.

Each INSAT satellite is the product of the well-orchestrated effort of the four major centres of ISRO. The main frame of the satellite which carries the controls, telemetry and telecommand, deployment and power systems is manufactured by the ISRO Satellite Centre at Bangalore, which also does the mission planning and analysis and manages the whole project. The gyro units, reaction wheels, and momentum wheels, to keep the satellite stable in orbit, are fabricated at the Vikram Sarabhai Space Centre, Thiruvananthapuram, which is also respon-

sible for the antenna reflectors and scanning mechanism for the Very High Resolution Radiometer (VHRR), that forms the main meteorological payload of INSAT. The VHRR itself is a contribution of the Space Application Centre, Ahmedabad, which also provides the communications transponders. Another vital component, the apogee boost motor (that takes the satellite from its transfer orbit to the geostationary orbit) and the thrusters (required for maintaining the satellite in its assigned slot in orbit) are manufactured at the Liquid Propulsion Systems Centre at Thiruvananthapuram. It is worth mentioning that although INSAT-2A and INSAT-2B were both launched by the European Space Agency's *Ariane* rockets, the entire orbit raising operation — a series of complex maneuvres to take the satellites to their assigned slots in the geostationary orbit — were carried out by ISRO scientists from the Master Control Facility at Hassan, Karnataka. This itself is a testimoney of the degree of indigenisation of the INSAT system.

While INSAT-2A and INSAT-2B are almost identical twins, INSAT-2C is planned to be different. According to INSAT Programme Director, Dr. K. Narayanan, INSAT-2C will have a KU band transponder which will make it possible to receive TV programmes using small roof-top terminals. It will also provide an experimental communication service which will make it possible to communicate from moving vehicles. Incidentally, INSAT-2C will not carry the meteorological payload as the ones on INSAT-2A and INSAT-2B are expected to provide service till 2003. But INSAT-2E, which is likely to be put into orbit sometime in 1998, will carry a improved version of the VHRR as the meteorological payload.



An artist's impression of INSAT-2A in orbit

WHILE with the success of INSAT-2A and INSAT-2B satellite technology in India can be said to have come of age, the same is not true in the case of launch vehicles. Of the four stages of satellite launch vehicle development programme of ISRO, only two — SLV-3 and ASLV — have been achieved so far. The first launch of the PSLV will have taken place by the time this issue is out. If successful, it would mean almost a 'quantum leap' for India's space programme. Powered by a massive 128-tonne solid propellant stages, the PSLV is designed to put a 1000-kg remote sensing satellite in a sun-synchronous polar orbit. Incidentally, PSLV's first stage is the third largest solid booster in the world after the American Titan and space shuttle.

According to Prof. U.R. Rao, Chairman of ISRO, Indian industry had a major role to play in the PSLV project. For instance, the special maraging steel used in the first stage was manufactured by Mishra Dhatu Nigam in Hyderabad and the motor cases by Walchand Industries and Larsen and Toubro. The liquid *Vikas* engines are made by Godrej and Boyce, Bombay and MTAR, Hyderabad, while the liquid propellants are being made by Andhra Sugar and Hindustan Organic. NOCIL is manufacturing the solid propellants, while the 12-storey tall moving tower for PSLV was fabricated by Triveni Structurals.

Even if the PSLV succeeds, however, the way will not be cleared for the next stage - the more powerful GSLV — for it would need an entirely

Master Control Facility at Hassan, Karnataka, the nerve-centre of Indian space research

different type of rocket engine, called the cryogenic engine. Unlike the *Vikas* engine used in the PSLV, which uses propellants which are liquid at room temperature, a cryogenic engine uses liquid oxygen and liquid hydrogen as the propellants both of which need extremely low temperature for storage. GSLV will use a cryogenic engine for its third stage.

According to the original plans, the cryogenic engines and the technology were to be procured from the Russian space agency Glavkosmos. But the restrictions imposed under the Missile Technology Control Regime (MTCR) has put an end to that option. Undeterred by this setback ISRO is now going ahead with its own cryogenic engine programme and hopes to be ready with the first full-scale prototype within two years. According to Prof. Rao, this will put back the GSLV launch by at the most three years.

Despite these setbacks, Prof. Rao is optimistic about the future. "Implementation of the well-planned Indian space programme in this decade", he asserts, "will not only establish total self reliance in space technology including the establishment of the rocket launching capabilities to launch the INSAT-2 class of satellites, but it will also open up new avenues to develop rural economy in the country. According to Prof. Rao, "the multiplier impact of the diffusion of tasks, skills. techniques and technologies is already beginning to show. A vibrant and dynamic space industry has emerged, cutting across the small, medium, and large private and public sectors. The planned involvement of Indian industries in the development of our space programme has already started paying rich dividends and in the coming years India has the potential of becoming a space industrial power in the world." □

INDIA'S SATELLITES

Satellite	Date	Result
ARYABHATTA	19 March, 1975	Success
BHASKARA 1	7 June, 1978	Success
ROHINI	10 August 1979	Failure
ROHINI	18 July, 1980	Success
APPLE	19 June, 1981	Success
BHASKARA 2	20 November, 1981	Success
ROHINI	31 May, 1981	Failure
ROHINI	17 April, 1983	Success
SROSS 1	24 March, 1987	Failure
IRS 1A	19 March, 1988	Success
SROSS 2	13 July, 1988	Failure
IRS 1B	29 August, 1991	Success
SROSS 3	19 May, 1992	Success
INSAT 2A	10 July, 1992	Success
INSAT 2B	23 July, 1993	Success

Solar Control Of The Atmosphere

The eminent scientist besides pursuing serious work also took pleasure in telling lay-men what his research is all about. A sample of the popular science writings of

M. N. SAHA

IT is a matter of common knowledge that weather and climate, so important to human life, are solely controlled by the sun. The understanding of this control mechanism has presented an eternal problem to mankind. In ancient communities, there were 'weather prophets' whose duty it was to foretell the weather and if possible, to control it with magic. In later times, their place was taken up by astrologers who are still found in many parts of the world issuing weather forecasts for the year.

Scientific study of weather and climate dates from the time of discovery of the barometer by Torricelli but from the very nature of things early meteorology could not find out a Newton, and it was realized that meteorological data must be patiently collected, classified and analyzed by a world-wide survey, before we can have any inkling of the secrets of the puzzling phenomena presented by meteorology. For the purpose, meteorological surveys have been organized almost by every state and a system of short and long range forecasting has been undertaken. But short-range forecasting owes, whatever success it can claim, more to powers of quick transmission of news which is rendered possible by modern discoveries in physics than to any profound insight into the nature of the problems involved. But what would really benefit mankind is a system of successful long-range forecasting, say 6 months or at least 15 days ahead. The meteorologist has not yet succeeded in this task. However, in recent years Franz Baur in Germany and Multanovsky In Russia have developed methods for medium-range forecasting which appears to have attained a certain amount of success. Their methods are

The influence of solar radiation on our atmosphere is evident during total solar eclipse

based on combination of synoptics and statistics, and in Franz Baur's method, atmospheric conditions at a height of 5 km are supposed to control the ground weather for the next 10 days. But no physical basis has yet been found as to why this should happen.

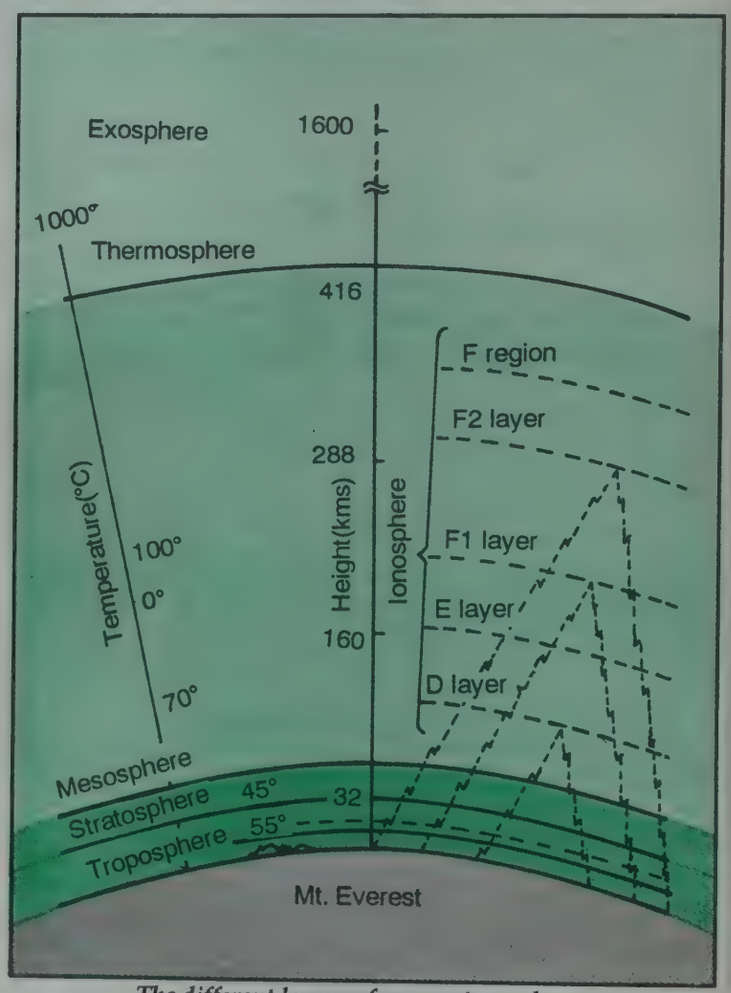
Formerly meteorologists thought that ground weather was controlled by the direct heating of the surface of the earth by the solar rays. So they neglected the study of the upper atmosphere. But in recent years, upper air surveys have been receiving greater and greater attention. There are the spectacular stratospheric flights, exploration of the upper atmosphere by radio-meteorographs, instruments which are carried in balloons and signal weather conditions upto heights of 30 km by radio. In view of the prospective use of the stratosphere for air travels and the use of still higher regions for radio propagation, probably the need will be soon felt for a better knowledge of not only the stratosphere but also of the still higher regions. Here photochemical action of solar radiation on the atmospheric gases plays the chief part. So we must have a good knowledge of the radiative properties of the sun and the constituents of the upper atmosphere, and the action of solar radiation on them which ultimately controls the ground weather.

OUR knowledge regarding the radiation from the sun is particularly defective in the ultra-violet region because the solar spectrum is abruptly cut off below 2900 A° (A°, or angstrom is a measure of the wavelengths of radiations like light). In 1881 Hartley showed that this abrupt termination of the solar spectrum below 2900 A° is due to a small amount of ozone present in our atmosphere. But ozone is not distributed according to the laws of hydrostatics as in the case of other gases in the atmosphere, but was shown by Fabry and Buisson in 1913 to be localized in the upper regions. A worldwide survey of the ozone content of the atmosphere has been initiated by Dobson, Gotz and Meetham. The amount of ozone present in the atmosphere is found to be not more than 3/10 cm of the gas at normal temperature and pressure, spread over the atmosphere layer from 20 km to 50 km, having a maximum density at abouty 30 km, but the amount undergoes variations which are clearly connected with meteorological conditions. The ozone itself is not an original constituent in the sense oxygen or nitrogen is, as in that case, instead of occurring at a height, it would have settled down at the bottom. It has been found that ozone is produced by photochemical action of the sunlight on the oxygen of the atmosphere in a way which is not yet completely elucidated.

We all know that there is no sunlight for about six months every year, in the polar regions. During these long winter nights the sky is frequently illuminated by brilliant flashes of light, called aurora or polar lights. Long ago, it was found that the brilliancy and frequency of these auroral lights were not constant from year to year, but varied in the same way as the spots of the sun, the period being nearly 10.32 years, roughly known as the 11 year period of the sun.

The close connection between sunspot activity and occurrence of aurora led Birkeland to the view that auroral phenomena were probably due to injection of streams of electrons coming straight from the sun and striking the atmosphere of the earth in a narrow jet, a view which he further confirmed by laboratory experiments which has been repeated in recent years. The streams of electrons on their entry into the atmosphere, are deflected by the earth's magnetic field and are focussed round about the magnetic poles. Paulsen, on the otherhand, thought that the swarm of electrons which produce aurora, does not come direct from the sun but are produced by the ultraviolet light of the sun acting photochemically on the constituents of the upper atmosphere.

The spectrum of aurora contains a prominent green line, the origin of which was unknown for a long time. This green line was ascribed to a hypothetical element, even lighter than hyudrogen, called geocoronium by Wegener. But when Moseley definitely proved that there was no place for such an element in the periodic table, it was found necessary to look for the origin of the line from amongst the known elements. This line was later found to be given by the oxygen atom when it is in a metastable condition by what is known as the forbid-



The different layers of upper atmosphere

den transition from one metastable level to another. This discovery shows that oxygen, contrary to hydrodynamical conceptions, is present in the auroral regions (30 km - 400 km) in the atomic state and in a peculiar state of excitation. Further examination of the spectrum of aurora reveals lines which have been identified with those of forbidden lines of atomic nitrogen. Thus spectroscopy has given us knowledge of the peculiar physical conditions prevailing in the auroral regions.

It is a well-known fact that if one observes the sky from the countryside far away from the city lights at the dead of night, the starless parts of the sky do not appear to be as dark as one finds himself in a light-tight room but appear to possess considerable luminosity. This must originate from the upper regions of the atmosphere for it is observed even at stations far removed from the magnetic poles, hence the luminosity must be due to other cause besides artificial stimulation by electrons which gives rise to aurora. The spectrum of the luminous night sky shows the same green line of oxygen and certain other band lines which have been identified with those of nitrogen. The important difference between the spectrum of the night sky and aurora is that, in the latter, bands due to ionized nitrogen predominate and lines due to uncharged nitrogen molecules are very feeble, whereas in the former case, the negative bands are faint and sometimes even absent but band lines due to neutral nitrogen molecule are extremely strong. The origin of the luminescent night sky must be traced to the fact that at these height sunlight is absorbed by the atmospheric gases in the day time and stored in some way and is reemitted at night. A closer examination of the phenomenon, therefore, promises to throw much light on the nature of the solar radiation, because the night sky phenomenon can be due to no other cause except the action of the ultraviolet rays of the sun below 2000 A° on the constituents of the upper atmosphere.

Thus it is clear that the luminescent night sky, and the aurora, both represent optical excitation of the constituents of the upper atmosphere but that under different conditions. The former is a purely photochemical excitation by a normal sun, the latter is due mto an *active* sun, and further complicated by the peculiar way in which the optical excitation is effected through the agency of electrons which according to one view, come directly from the sun but according to the other view, are photoelectrically liberated in the outer regions of the sunlit parts, but are deflected by the field of the earth towards the magnetic poles.

THE solar control of the part of the magnetic field of the earth due to external causes is illustrated by disturbances of two types. An erratic one called magnetic storms was first observed by Celsius in 1741, who found that the coming of the aurora was heralded by a certain amount of restlessness of the magnetic needle. Magnetic storms have been found, in general, to occur in greater intensity and frequency simultaneously with periods of solar activity indicated by spots and aurora. The second type of disturbance is of more regular nature and shows a diurnal and a monthly period. At sunrise, the north-seeking pole of the needle is slightly east of its position, at noon, it points approximately to its mean position, towards sunset it moves to the west and regains the mean position again at midnight. The daily disturbances of this type are caused by the horizontal movements of the electrons (that is electric current) in the upper atmonsphere across the vertical field of the earth's magnetism.

ABOUT three years after the famous experiments of Marconi in transmitting electro-magnetic waves from England to America, Kennelly and Heaviside almost simul-

The luminescent night sky and the aurora represent excitation of constituents of upper atmosphere under different conditions

taneously proposed that the upper atmosphere contains a number of free electrons which form a sort of metallic shield about the earth, reflecting wireless waves and thus keeping them confined within a narrow shell about the earth. At the present times, it is known that the electrons which act as reflectors of wireless waves are stratified in different layers of which two are permanent. They are known as E_1 (at about 100 km height) and F_2 (at about 200-250 km). Methods have now been perfected for finding out the night and day variations of the height of these layers and their maximum electron concentration and so on. In addition to these permanent layers there are also subsidiary ones. There were long controversies regardinag the origin of these layers. Birkeland proposed that these layers were formed by electrons coming direct from the sun while others maintained that they were due to electrons liberated by the ionizing action of ultraviolet sunlight. The problem was solved in a decisive way during the total solar eclipse of 1932. Experiments showed conclusively that at least in the E and F_1-regions the electrons were produced by the ultraviolet sunlight because as soon as the total olight from the sun was cut off, the density of electrons fell to a very small value.

A thermodynamical theory of ionization in the upper atmosphere by the ultraviolet rays of the sun was worked out by Prof. Pannekock of Amsterdam in 1926, by extending

Milne's modification of the Theory of Thermal Ionization first given by the present author. Chapman on the other hand, folowing an earlier work by Lenard worked out a mathematical theory of production of electrons by monochromatic light which as has been shown later by R. N. Rai and the author, is implicitly contained in the fuller theory of Pannekock.

Chapman's work was insufficient in one respect, namely that it was proved only for monochromatic light whereas if we suppose the sun to be a black body at 6000 ° K, the ionizing radiation should consist of the whole spectrum beginning from a certain limit and extending indefinitely towards the ultraviolet. It could not be seen off-hand, if ionization by such a spectrum would not destroy much of the properties of the layer. But in the revised theory, it so happens, and it is a rather unexpected result that even continuous spectrum produces a layer very much similar to the simple one of Chapman. The form of the layer depends, to some extent on that of the photo-ionizing absorption curve which is not yet known for the ionization processes actually occurring in the atmosphere, but is only deduced from a plausible theory. These various considerations lead us to the conclusion that the different stable leyers as observed in the ionosphere are due to ionization, by the appropriate solar radiation, of distinct constituents of the atmosphere, namely, nitrogen, oxygen, atomic nitrogen and atomic oxygen; the maximum of the layer occurring at the height where total absorption of ionizing radiation by the particles reaches its maximum value.

The E_1-layer must be due to a process of ionization which is effective only at a height of 100 km. As the amount of oxygen and nitrogen above this height is of the order of a few centimetres, the radiation which causes E-layer ionization should be such that it can be transmitted through a few centimetres of nitrogen and oxygen gas at the normal atmospheric temperature and pressure. These considerations prove that the E-layer is probably formed by the first process of ionization of oxyugen and nitrogen at 12.2 and 15.5 volts. The F_2-layer on the other hand, should be due to ionization by radiation which can be stopped by by about 0.001 millimetres of the gas, because at a height of 200-250 km, where this layer is formed, the amout of the gas lying above cannot exceed this amount. We can easily link up this fact with the second ionization of nitrogen and oxygen which gives rise to excited oxygen and nitrogen, because the ionization occurs with an intensity which is about 1,000 times stronger than the first ionization. The calculated pressure is of the order of 10^{-6} to 10^{-7} millimetres which is of the order of pressure at the F-layer. The F_1-layer is a purely daylight phenomenon. It is found that the night F-layer split up into F_1 and F_2

Balloons like this carrying instruments in to upper atmosphere have given us a greater insight into the solar control of atmosphere

when the sun is sufficiently high up in the sky and towards nightfall, when the sun's altitude has fallen, F_1 and F_2 unite to form one, single layer. The F_1-layer is probably due to an extra process besides ionization, which is operative only during day time. During day time, the oxygen molecules probably completely dissociates into atoms at a height of about 200 km on account of absorption of radiation between 1750 A° and 1300 A°. The electrons which give rise to the F_1-layer must be due to further ionization of the oxygen atoms, produced during daytime. At night or when the sun is sufficiently slanting, probably most of the oxygen atoms at this level would recombine to form molecules and therefore F_1-layer will disappear, as there are not sufficient oxygen atoms to be ionized.

THUS E_1 and F_1 are controlled completely bya the sun but the F_2-layer behaves anomalously. During the time of total eclipses, the F_2-region ionization appears to remain unaffected. This and other facts show that either the solar control theory is insufficient for this region or that while working out the theory of photo-ionization we should not regard the system to be a unicomponent one. Probably in the F_2-region the pressure is so low that collision between electrons and ions must be extremely infrequent, and neutralization takes place after intervals of the same order of magnitude as the day and hence the equilibrium theory has probably to considerably modified.

It must not be supposed that the theory of solar control can explain all the characteristics of the ionoxphere except the F_2 region. Rather puzzling is the persistence of ionization in the E-region at night. The E-region should entirely disappear as soon as sunlight is withdrawn, because in this region collision frequency is quite large (10^5/second), and recombination must be very quick but we find that there is a residual ionization about 1/20th the maximum amount, which is present throughout the night. It does not appear probable that this is due to positive ions. We must therefore suppose, that at night, there is probably some mechanism at work by which fresh electrons are produced. It is not improbable that a neutral molecule colliding with a negative ion might knock out the electron and supply the electrons forming the residual E-layer at night.

A complete theory of the various puzzling ionospheric phenomena will probably take years of work. Much depends on the correct interpretation of the results obtained by the methods of reflection of radio waves from the ionosphere. It need not be supposed that the magnetoionic theory of propagation of electro-magnetic waves which is now holding the field is infallible.

IT has been observed for some years that radio signals, which were being received from a distant station, sometimes suddenly stop and the normal conditions are obtained after lapse of time which extends usually over a few minutes. Observations showed that many of these sudden fadeouts were simultaneous with the apearance on the surface of the sun of small bright patches of intense white light. From the international programme carried out by Dellinger and Jauast, it was found that the phenomenon is confined only over the sunlit part of the globe and that it starts simultaneously at all (sunlit) stations. The radio fadeout was connected with intense chromospheric eruptions, though all eruptions did not give rise to radio fadeouts. Further investigations showed that neither the ionization nor hieght of the E and F layers were very much disturbed furing these sudded radio fadeouts. The cause of the disturbance must, therefore, be sought below the E-region or in an intense transitory ionization of the regions belowm E which is sometimes called D by the British astronomer, Appleton. This is further confirmed by increase in intensity of long-distance radio by means of very long waves during radio fadeouts, which refer only to short and medium waves, because long waves are reflected from the low that D-layer. Further, radio fadeouts are accompanied by magnetic disturbances of short duration, which are strongest over the part of the globe durectly under the sun at the time of eruption. This shows that the small patches send out a flare of ultra-violet light which produces intense ionization of the D-region.

The above review shows that though it is easy to say that the atmosphere, the upper as well as the lower, is entirely controlled by the sun, it is very difficult to work out the details and present a complete unified theory.

A complete theory of puzzling ionospheric phenomena will probably take years of work

For this purpose, we must know more about the normal behaviour of the sun, as well as of its abnormal behaviour which manifest in the form of spots, prominences, faculae and and small patches of intense light responsible for radio fadeouts and so on. All the astrophysical theories of the sun, giving a quantitative idea of the formation of Fraunhofer lines are somewhat unsatisfactory. There is no reason to suppose that the emission from the sun in all wavelengths should be black body radiation at a temperature of 6000° K. Moreover, the common notion that the sun radiates like a black body appears to be wide of the mark, particularly in the ultraviolet region. Many difficulties would be solved if a spectrum of the sun could be secured at a height of 40-50 km, that is considerably above the ozone layer.

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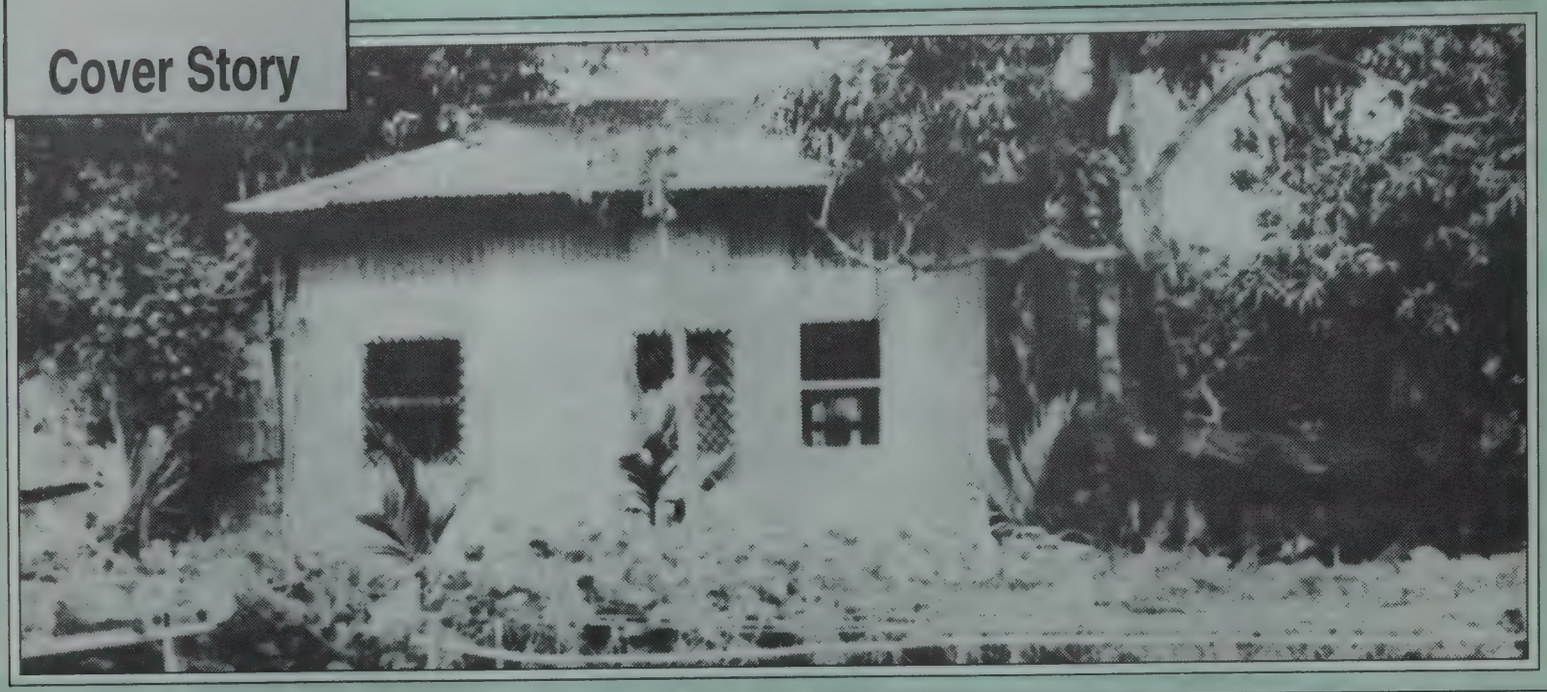
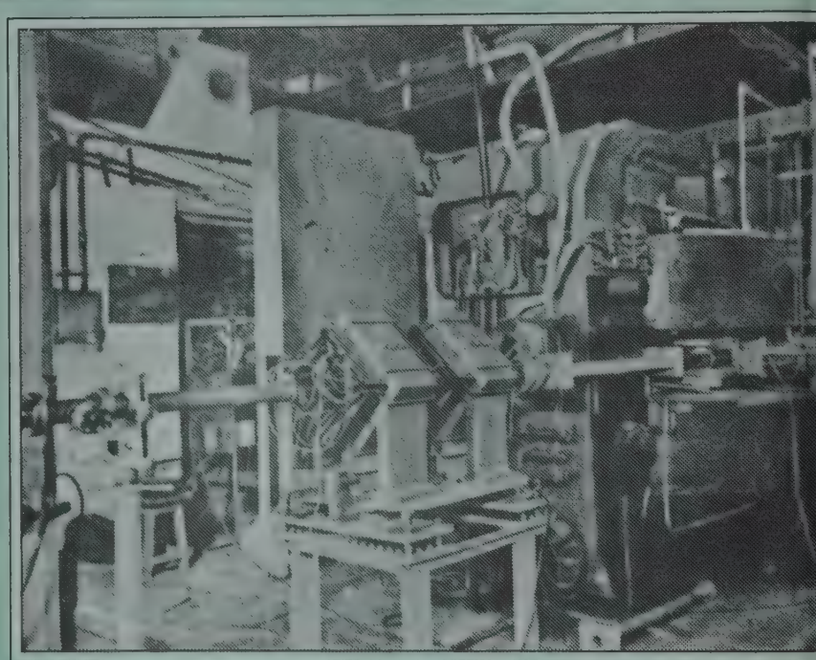


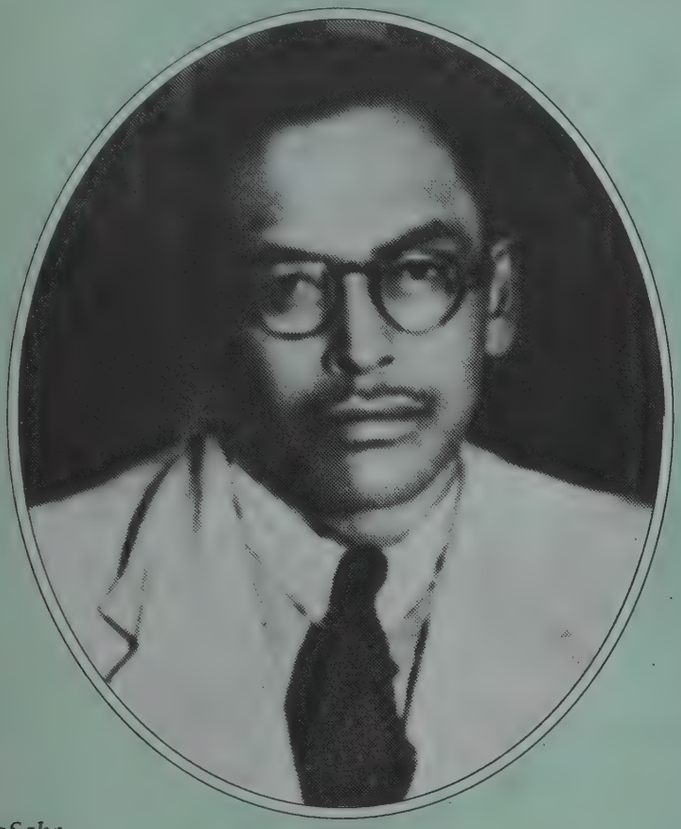
Saha's home at Seoratali Village

SAHA ALBUM

(Pictures courtesy: Birla Industrial And Technological Museum, Calcutta)



The first cyclotron set up at Calcutta University (right). Saha with Eddington at Allahabad (below)



Young Saha

Wife Radharani

The Saha Institute of Nuclear Physics and its founder

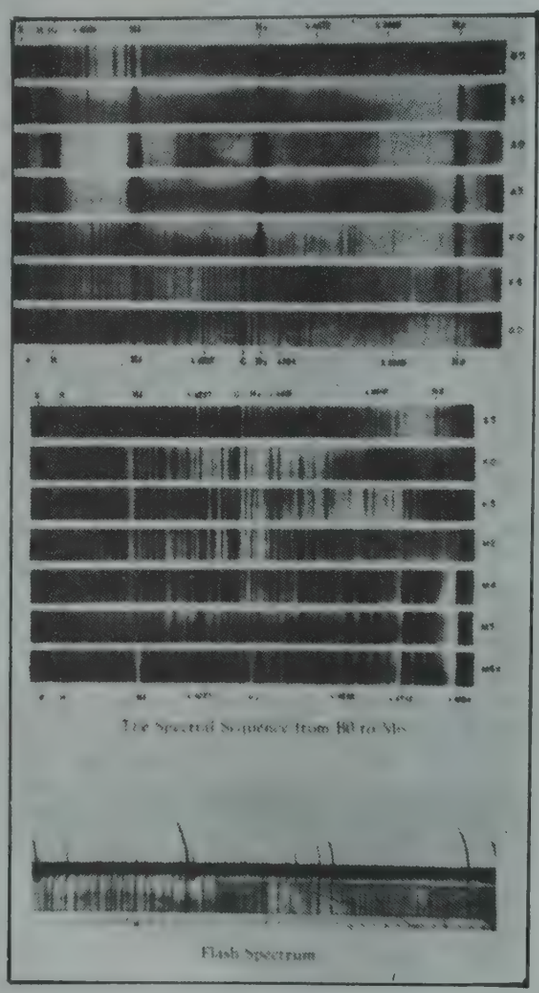
MEGHNAD SAHA

(Continued from page 11)

Calcutta University, he founded the department for nuclear physics which grew into the Saha Institute for Nuclear Physics.

It is often proclaimed that research and teaching should go hand in hand. However, one has seldom seen, at least during the past few decades, front rank scientists keen on teaching. Saha had the vision to appreciate the importance of teaching. He observes, "It was while pondering over the problems of astrophysics and teaching thermodynamics and spectroscopy to the M.Sc. classes that the theory of thermal ionization took a definite shape in my mind in 1919." (emphasis mine). Saha took teaching seriously, producing in 1931 his famous book *A text-book of Heat* which has gone through numerous editions and is used all over the world as a text-book.

SAHA was a remarkably impressionable mind. As a young man he had seen flood disasters, worked in voluntary relief groups, and had seen poverty at first hand. His intellect could not have failed to notice the mismanagement at every conceivable level. In his life as a physicist of repute he devoted his erudition and expertise in science and technology to tackle these problems. Saha wrote a series of essays on floods, river management, irrigation and other allied topics. It is interesting to note that as early as 1933 he had pleaded the case for establishing a Hydraulic Research Laboratory and for promoting irrigation research in India. Saha was the chief architect of the Damodar Valley Project which he had proposed in considerable detail in 1944. Saha also write a large number of scholarly articles in *Science and Culture*, which was started in 1935 at his initiative, on several aspects of organizing science and planning for a sound technological base for India, dealing extensively with issues, like, developing energy resources, coal, electricity and nuclear power. Rarely does one find a scientist of his calibre so deeply concerned about the well being of his countrymen.



A spectrograph

Unfortunately, his views on economic development and planning did not receive the attention they deserved. Saha had listened passionately to top leaders like, Pandit Nehru and Subhash Bose who had painted rosy pictures of a prosperous India. Saha, who participated actively in these discussions during the freedom struggle, was bewildered by the policy documents and plan proposals blessed by Prime Minister Nehru. In his famous essay, *'Rethinking Our Future'* Saha recalls Panditji's words in the *Discovery of India*, "....a really progressive standard of living would necessitate the increase of national wealth by 500 to 600 percent. That was, however, too big a jump for us, and we aimed at a 200 to 300 percent increase within ten years". Sahs takes into account all the prevailing conditions and the nature of the plan to conclude, *"At this rate, the per capita income will be doubled in 100 years."* (emphasis original).

This is not a solitary instance of Saha's critical writing. He wrote numerous articles based on an in-depth study of developmental plans of several countries, exposing critical lacunas in our five year plans, expressing his fear that India may not even catch up with Poland by teh turn of this century. His criticism was sharp and fortright. In his letter to Panditji, Saha says, "...if the plan be not altered root and branch, it will perpetuate our *"Colonial Status"* in the economic field, and greatly jeopardise our hard-won *"Political Freedom"*. (emphasis original). Critical of the neglect of the population problem, Saha observes, "In an over-populated country like ours, the rate of population growth should be kept down as far as possible....It does not appear possible that the government can take much active steps in this direction except by propaganda and education. This must be left to "God" for the present."

Thus spoke Meghnad Saha. Like most great men, his life spoke more eloquently than the written word. Here was a physicist par excellence, willing to devote his time to undergraduate and post-graduate teaching, ever willing to set up worthwhile laboratory programmes for his students, an institution builder with a deep commitment to the application of S&T for national development, and an even deeper concern for social justice. To inculcate this spirit would be the best way to remember him.

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STELLA MIRA

The Wonderful Star

What is the secret of the variations in brightness of the wonderful star, reveals
K. SMILES MASCARENHAS

THE star is known by several names. Mira, Stella Mira, Omicron Ceti, O Ceti, Collum Ceti. Mira is derived from the same Latin word which has given birth to the word miraculous. What is so wonderful about this star ?

Mira is a variable star. That is, its brightness is not constant, but varies in an almost regular fashion. True, there are many other stars which vary in brightness, but Mira is incomparable. Sometimes it rivals some of the brightest stars in the sky. At other times it can be spotted only through a good optical telescope.

Although many observable properties of a variable star may be changing at the same time, it is changes in the visual brightness that is the easiest to measure. The magnitude scale is a logarithmic one and each magnitude represents a factor of 2.5 times in brightness. Thus, a first magnitude star is brighter than a second magnitude one by a factor of 2.5 and a second magnitude star is brighter than a third magnitude one by a factor of 2.5. Incidentally, a star with zero magnitude is brighter than a first magnitude star by the same factor and stars with negative magnitudes are still brighter. On a clear night, the human eye can detect stars upto a magnitude of +6.

Variable stars can be broadly classified as eclipsing variables, like the star Algo (in the constellation of Perseus) and intrinsic variables, the stars which vary in brightness because of physical changes. Intrinsic variables can be further classified as long-period variables and short-period variables. Short-period variables, like the Cepheid variables, have a period of few days. Long period variables have a period of a hundred to five hundred days. The period of Mira averages 331 days and therefore it qualifies as a long-period variable. For Mira there are often considerable irregularities both in period and the maximum brightness attained. The brightness of Mira varies from 9th magnitude or less at minimum to about 3rd magnitude at maximum. Rarely it attains 2nd magnitude but it was reported that it attained 1st magnitude in 1779.

Mira was the first of the long-period variables to be discovered. The Dutch amateur astronomer, David Fabricius was the first to notice something unusual about the star. Fabricius was a Pastor in a local church. So, apart from preparing and preaching a sermon on Sunday he had plenty of time to devote to the study of the sky. On the morning of August 13, 1596, Fabricius was engaged in observing the planet Mercury. He attempted to measure the angular distance between the planet and a 3rd magnitude star in the constellation of Cetus, the Sea monster of the Perseus legend. Cetus is not a very prominent constellation with the brightest star in its group, Diphda, having a magnitude of only +2. The 3rd magnitude star which was never seen before Cetus attracted his attention. Having an excellent knowledge of the night sky, he continued to observe the star and noted that it vanished in a few week's time. He mistook it for a nova and missed the chance of making an important discovery. His career was cut short in the most tragic manner. He was murdered.

It was only in 1603, wqhen Johann Bayer compiled his famous star catalogue that this star was rediscovered. Without realizing its variability, he included it in his catalogue as a 4th magnitude star and assigned it the Greek letter Omicron.

The variability of the star was first noticed in December 1638 by a Dutch astronomer, Johannes Phocylides. He was observing a total lunar eclipse and saw the wonderful star once more. Checking back the records, he found that the star was not only detected by Fabricius and Bayer, but also by the German astronomer Schickard. Three

novae in the same position was obviously improbable and Phocylides realized that the star was a variable star. Then in 1648, the German astronomer, Hevelius, one of the leading astronomers of that time, named it Mira, (pronounced Meera), the wonderful star.

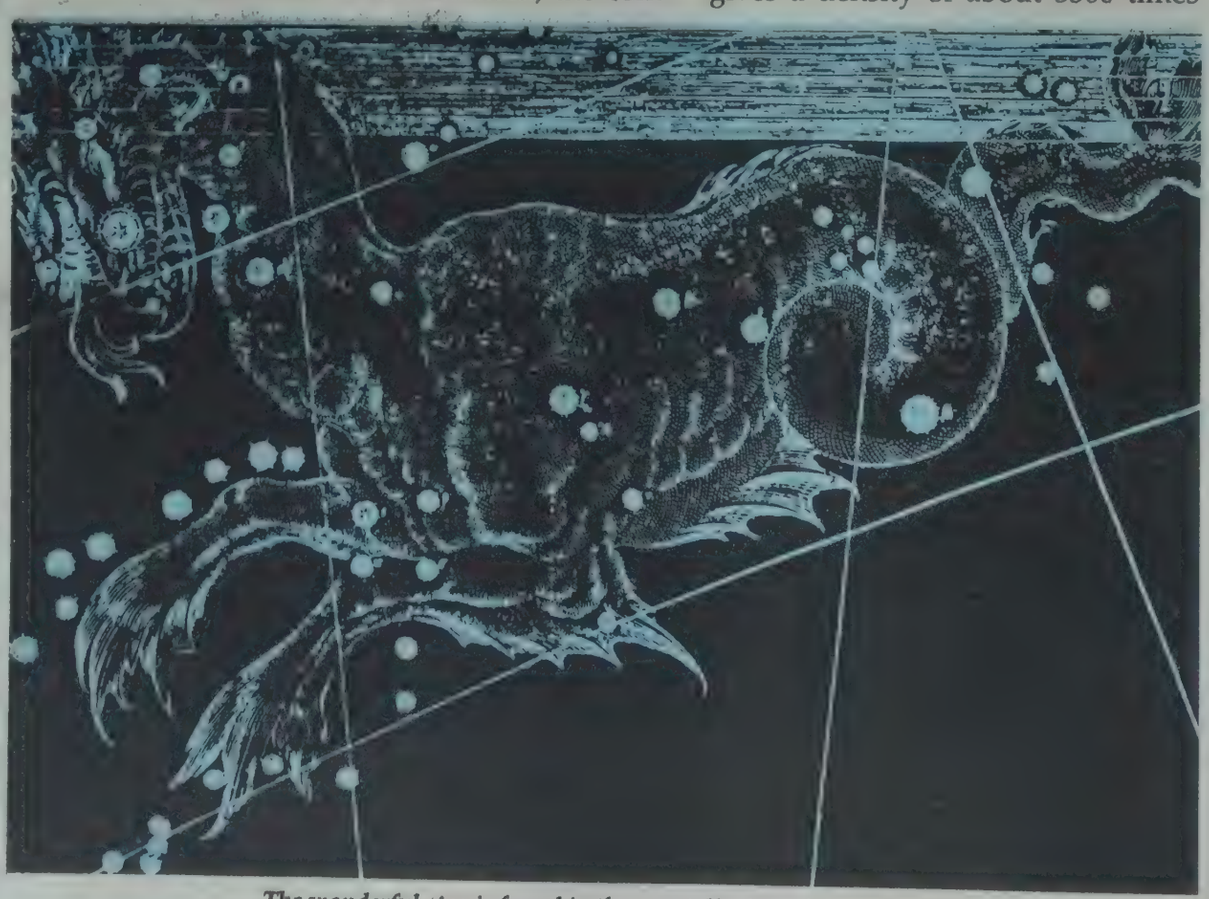
All the other subsequently discovered long-period intrinsic variable stars with a magnitude variation greater than 2.5 were called Mira variables. These stars were found to be exceptionally cool red giants with very low surface temperatures. In the case of Mira, radiometric observations showed that the surface temperature is about 1900 K at minimum brightness and 2600 K at maximum brightness. The ratio of these temperatures is 1.37. According to Stefan's law, the total energy radiated per square centimetre of a hot surface is proportional to the fourth power of the temperature. Therefore, at maximum, each unit of Mira's surface radiates $1.37^4 = 3.5$ times as much energy radiated at minimum. Yet the visual change in magnitude is about a hundredfold! Several effects seem to explain this paradox. First, cool stars like Mira radiate chiefly in the infrared and infrared radiation can not be detected by our eyes. When the temperature increases, the amount of visible radiation is dramatically increased. The variation at infrared wavelength is much less than in the visible range. Second, the radius decreases by about 20 per cent but this accounts for only 40 per cent change in surface brightness. Finally, changes in the transparency of the outermost layers to visual radiation, due to the formation of carbon particles, also play a part in the decrease in brightness, as the stellar atmosphere would be dimmed by the "soot". But the energy absorbed by this layer would be re-radiated in the infrared wavelengths. Taking the effects in toto it may be seen that Mira is at its maximum when its diameter is close to minimum.

The distance of Mira, from direct parallaxes and other criteria, appears to be close to 220 light years (one light year is the distance travelled by light in one year). The angular diameter of Mira was first measured by F.G. Pease in 1925 with a large interferometer at Mount wilson. It is currently believed that Mira has a diameter about 400 times that of the Sun. According to some estimates it may attain a diameter 500 times that of Sun, when at maximum.

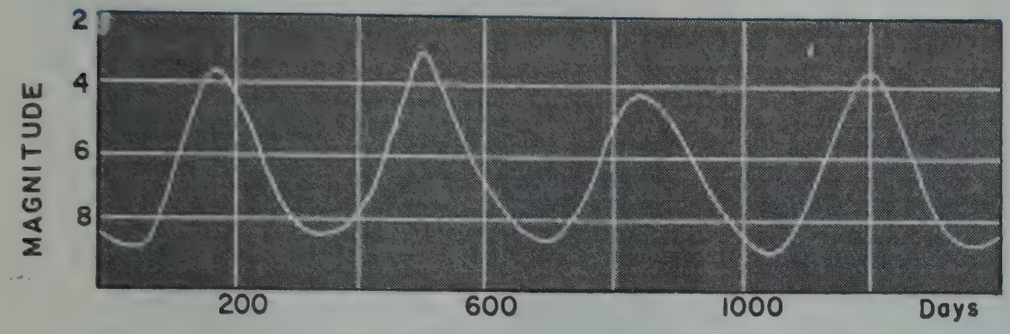
In 1918, A.H. Joy had detected peculiarities in the spectrum of Mira which indicated the existence of a B-type companion (A typical B-type star has a surface temperature of around 18000K and exhibits spectral lines of neutral helium atoms). In 1923, when Mira was at its minimum, the companion was seen visually for the first time by R.G. Aitkin with the 36-inch refractor at Lick Observatory. The colour was noticeably bluish, agreeing with an estimated spectral class of B8. As a strange coincidence, the companion is also an intrinsic variable, varying in magnitude from 10th to 12th magnitude in an erratic manner.

The orbital elements of the Mira system are of great importance, since they would reveal the mass of the red giant star by the application of Newton's law of gravitation. The result is startling. The blue companion seems to have a mass of 2.5 solar masses (one solar mass is equal to the mass of the sun, nearly 2×10^{30} Kg) and the red giant "primary" has a mass of just 1.5 solar masses! "This implies that its overall density must be very low indeed: about 2×10^{-7} that of the Sun, or almost close to the density we could attain in a "laboratory vacuum"!

The blue companion is a peculiar object; a hot sub-dwarf lying in between an "average star" and the true white dwarfs. Its estimated diameter is about one tenth that of the Sun; this gives a density of about 3300 times



The wonderful star is found in the constellation of Sea Monster



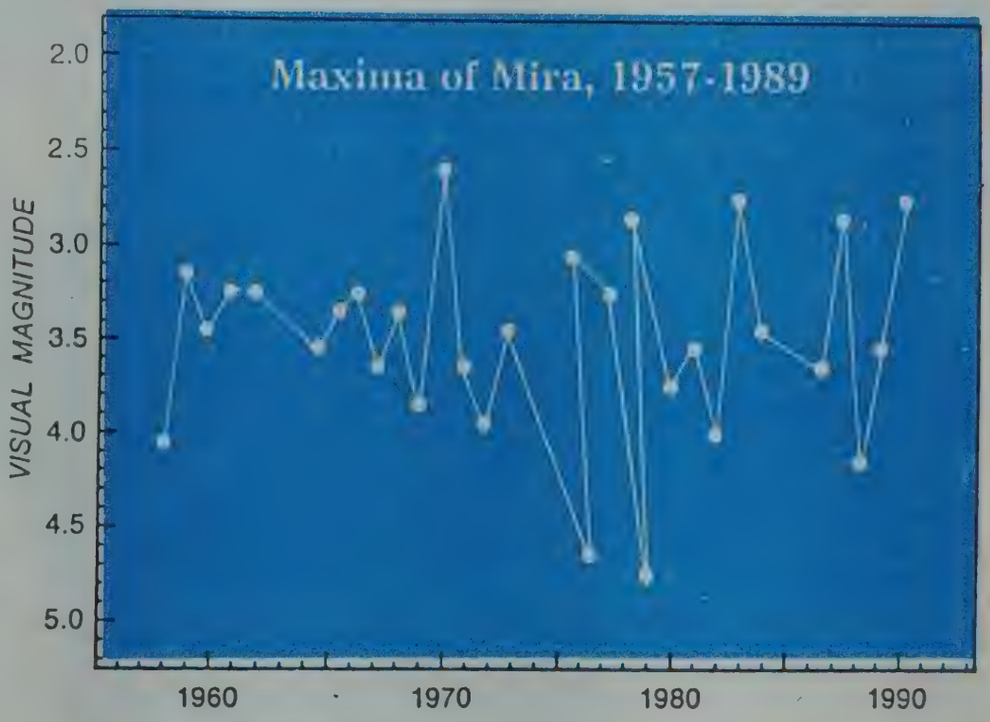
A typical four-year light curve of MIRA

that of the Sun. The estimated periodicity of the orbit is about 260 years. The stars must be separated by a distance of atleast 8 billion kilometres.

Although an isolated white dwarf continues to cool indefinitely, the companion of Mira can remain luminous for much longer. The dense stellar wind emitted by Mira crashes on to the surface of its companion releasing enormous amount of energy. this energy is then radiated by the companion.

The early theories to account for Mira's variability ranged from implausible to ingenious. Some astronomers imagined the the star to be a rotating globe which is very dim with a bright hot spot; others suggested that the star was a highly elongated body which showed different brightnesses when viewed at different angles. Sir William Herschel, who observed Mira in 1777-1780, said that the star was surrounded by Saturn-like rings which were sometimes seen face-on, at other times edge-on. It was not until 1926 that Sir Arthur Eddington showed that the variations were due to the pulsations of the atmosphere of the star.

Why do pulsating stars pulsate? Eddington proposed a hypothetical "value" near the surface of the star. He then analyzed the star as a heat engine which converted some of its thermal energy into mechanical energy. If the valve closed, trapping heat when the star was hottest and most compressed, and then opened, releasing heat when the star was coolest and most expanded, then the requirements for a heat engine would be satisfied. Eddington suggested that the natural opacity of atoms in a star



The brightness of Mira is not the same at every maxima

could provide this valve. The atoms in the interior of most stars are fully ionized (that is stripped of all electrons) and the valve failed to operate. But there is one situation where the valve worked, and that is when the atoms are only partially ionized. The pulsation theory was taken up by other workers and with the advent of modern electronic computers it became possible to compile elaborate tables of the opacity of matter in a star with respect to temperature and density. The valve theory satisfactorily explains the pulsation of short period Cepheid variables, but not very well for Mira variables.

We know for sure that atleast the outer layers of Mira are expanding and contracting. But the reasons for the pulsations are not very clear. It is quite probable that the red giants are very old stars which are nearing the point of hydrogen exhaustion and in which the next reaction, helium burning, is about to begin. The pulsation could be attributed to the onset of the helium reaction which sends a shock wave through the outer layers of the star after having originated in some disturbance in the interior. When a star pulsates, it expands past its equillibrium size until the expansion is slowed and reversed by gravity. Like a pendulum, the star overshoots its equilibrium size once again and continues to contract. As the gas pressure within the star builds up, the contraction is slowed and the surface is pushed outward again. The helium burning process must be overcoming any damping effect.

Spectroscopically, Mira is a remarkable object with its strong dark bands of titanium oxide and its bright emission lines of hydrogen which are the typical features of all the long-period variables. Because of the star's cycle of expansion and contraction, its surface alternately approaches and

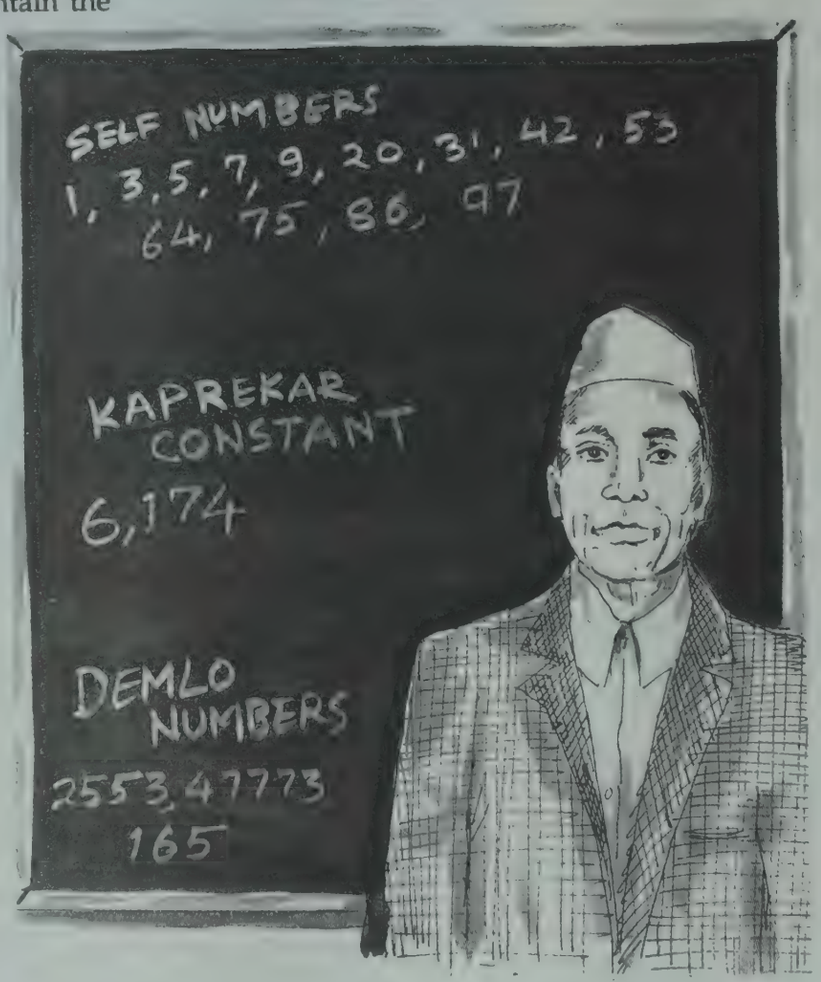
(Continued on page 37)

D. R. Kaprekar

The man with a bagful of mathematical tricks

DILIP M. SALWI

IT is often remarked that a message from an alien being or an alien world would contain the value of pi (π) some prime numbers, physical constants, and so on. These values and numbers are well known and their presence in an interstellar message would indicate the mathematical acumen of the aliens. But, what would happen if a number such as 6,174 pops up instead in the interstellar message ? Few astronomers - still fewer Indian astronomers - in fact, only those who have read Martin Gardner's columns on mathematical recreations - would be able to decipher what the number 6,174 stands for. 6,174 is now universally known as the Kaprekar constant, named after its discoverer, Dattaraya Ramachandra Kaprekar, the mathematician who was laughed at by most contemporary Indian mathematicians for his 'trivial' play with numbers and who died almost unrecognised and unsung at the age of 83. Perhaps, had that American mathematics populariser Martin Gardner not noticed his work and not mentioned his contributions in his *Scientific American* columns in 1975, Kaprekar would not have received the little recognition that he received before his death.



His mathematical contributions appeared so simple—needed only a pencil and some paper—that few mathematicians used to complicated theories and equations, could appreciate their worth. Today, Kaprekar constant and his other important contributions to the field of numbers, namely, self-numbers, demlo numbers, etc, are recognised the worldover for their recreational value.

Kaprekar was born at Dahanu, near Bombay, on January 17, 1905. When he was barely eight year old his mother died. His father, who was a clerk in revenue office, tried to teach him whatever little mathematics he knew. Being an expert astrologer he taught young Kaprekar astrology. As astrology is a play of numbers, young Kaprekar was introduced to the world of numbers through it. Numbers fascinated him so much that he began to play with them round the clock. Calculations thrilled him. His goal was to solve a mathematical problem in the shortest possible way. Soon, mathematical puzzles, tricks and doubtful and difficult questions caught his attention. During his school days at Thane, some of his classmates used to laugh at him for wasting his time on numbers; others watched him with fascination and admiration as he played with numbers. In 1923 he joined Ferguson College, Pune, where he received the Wrangler R.P. Paranjpe Mathematical Prize for his original piece of mathematical work. After graduation he took up a teachership in a school at Devlali, near Nasik,

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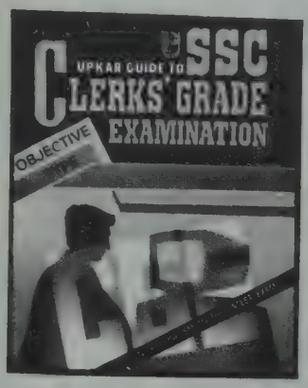

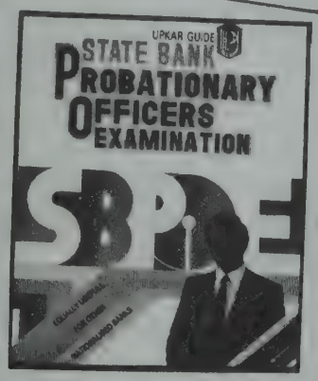

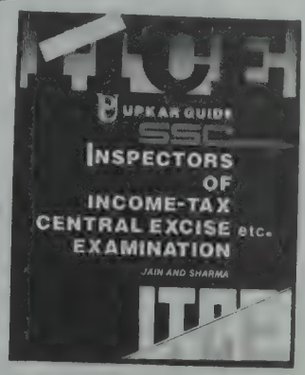

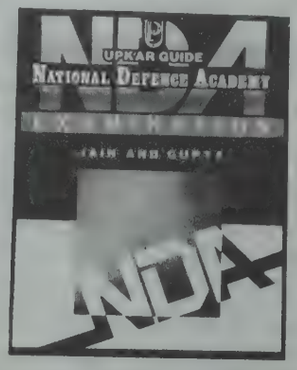

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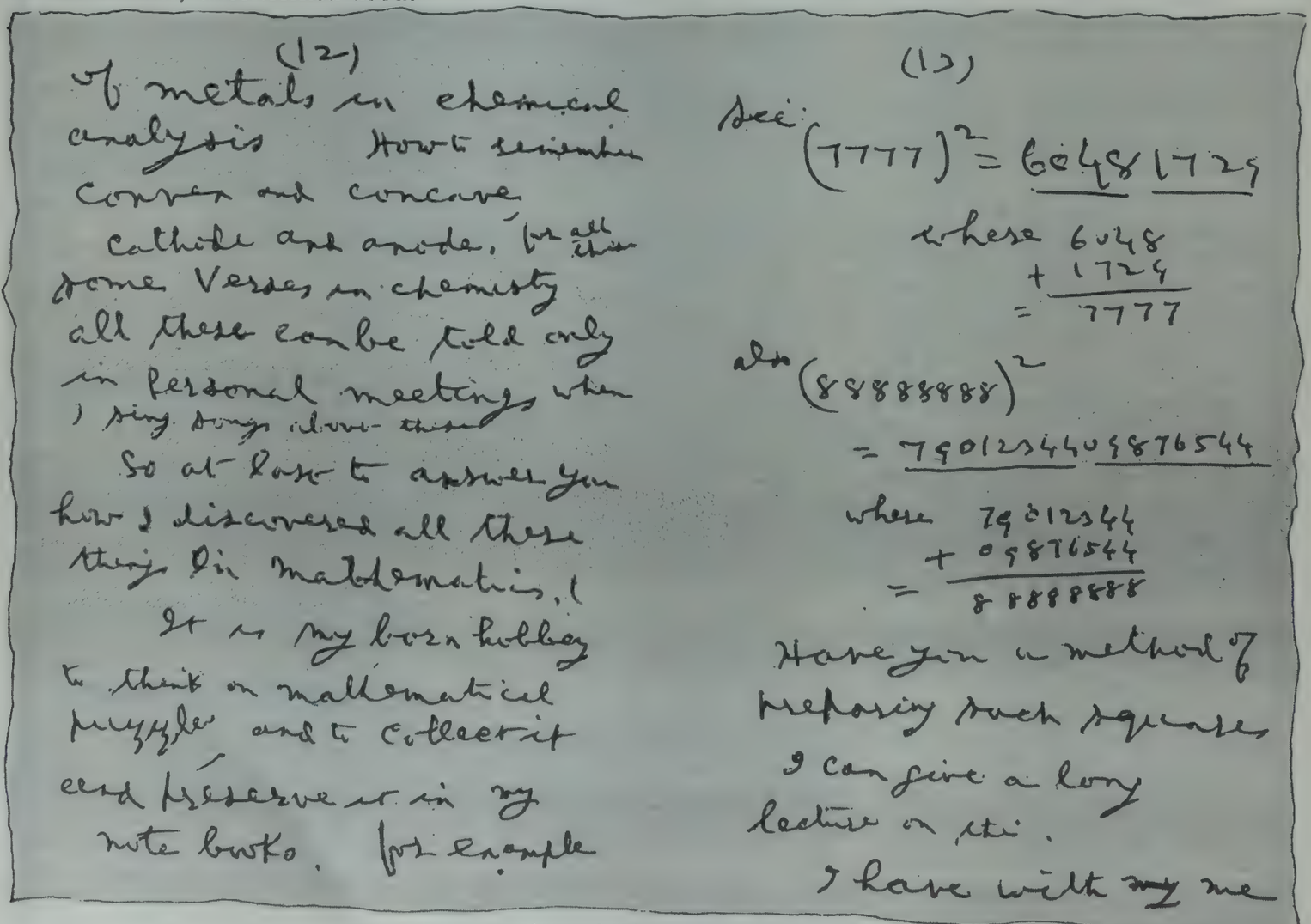
Unsung Men Of Science

Maharashtra. He continued to teach in various schools in Devlali till his retirement. Intelligent students and teachers admired him and appreciated his method of teaching mathematics. Kaprekar had the knack of imparting the joy he himself felt while playing with numbers to his students and other teachers. He was therefore often called upon by various schools and colleges to deliver talks and lectures on numbers, mathematical puzzles and curiosities.

"A drunkard wants to go on drinking wine to remain in that pleasurable state. The same is the case with me in so far as numbers are concerned," Kaprekar once remarked about himself. Give him some sheets of paper and a pen with enough ink, and Kaprekar would be lost in the world of mathematics, unconcerned about food and clothes. Often he would tie a rope instead of a belt, would carry biscuits in his pockets in case he suddenly became hungry while playing with numbers, and would treat everyone, whether his principal or students, with equal humility and respect. Simple by nature and a deeply religious person, he had a child-like attitude towards life and mathematics. He was therefore often misunderstood. Most Indian mathematicians scoffed at his discoveries and laughed at his antics calling them "too trival" to deserve any notice. Nevertheless, Kaprekar continued his play with numbers, got his discoveries published in Indian and foreign journals and corresponded with western mathematicians working in number theory.

In 1962 Kaprekar was forced to retire at the age of 58 when he was drawing a monthly salary of Rs 150. Naturally, he could not have had enough pension to make his two ends meet. Four years later, his wife passed away, leaving him alone to fend for himself. To survive he began to take tuitions in mathematics and science, and started charging a nominal fee for his lectures and talks on recreational mathematics. But as the saying goes, when the spirit is willing nobody can stop a person from achieving what he has set himself for. He used to cook his own food, wash his own clothes and perform all household chores. When he fell ill, his neighbours and students used to look after him. Despite all odds he continued his pursuit with numbers, spending as much as 15 hours on them every day. He also began to publish booklets on his discoveries, puzzles and problems. For publishing some booklets he received grants from some Indian universities. His books, 30 in all, are easy to understand for undergraduate students and


(12)

of metals in chemical analysis. How to remember convex and concave, cathode and anode. For all these some Verses in chemistry all these can be told only in personal meetings when I sing songs about them.

So at last to answer you how I discovered all these things in Mathematics, I

It is my born hobby to think on mathematical puzzles and to collect it and preserve it in my note books. For example

(13)

See: $(7777)^2 = 60481729$

where 6048 + 1729 = 7777

also $(88888888)^2$

$= 7901234409876544$

where 79012344 + 09876544 = 88888888

Have you a method of preparing such squares I can give a long lecture on it.

I have with me

A sample of Kaprekar's writing

have stimulated several amateur mathematicians to take up recreational mathematics. Indian mathematicians began to recognise his contributions only after Martin Gardner wrote about him and his discoveries in his popular 'Mathematical Games' column in the March 1975 issue of *Scientific American*.

Throughout his life Kaprekar was only interested in number theory, the branch of mathematics which has much recreational and entertainment value but no direct use or application in any other field. Take, for instance, the Kaprekar constant 6,174. It is a constant in one sense. Take any four digit number such as 7823 in which not all digits are alike. Arrange the digits in descending order and reverse them to form a new number; 7823 becomes 8732. The reversed number is 2378. Subtract the new number from the first number. 8732 minus 2378 is equal to 6354. Again, arrange the digits in descending order, reverse them, and substract the new number from the first number. For instance, 6354 becomes 6543 and reversed becomes 3456; then 6543 minus 3456 is equal to 3087. This is what is called "Reverse substraction process", which if repeated with remainders, leads to Kaprekar constant after eight or more steps. The constant generates itself thereafter. Today, this constant may sound trivial but it took Kaprekar about three years of juggling with numbers without the aid of a calculator or a computer to discover it. He began calculations from a lower number and slowly worked his way up until he discovered the constant. He announced his discovery at the Madras Mathematical Conference in 1949. The American journal *Scripta Mathematica* subsequently published his paper on the constant.

In 1949, Kaprekar also discovered what he called "Self-numbers" - *Swyambhu*. He later proved that there are infinite such numbers. To understand self-numbers, one has first to know what Kaprekar called "Digitadition". Take any positive integar and add to it the sum of its digits. For instance, for 47, 4 plus 7 is 11; 47 plus 11 becomes 58. The new number 58 is called a "generated number" and 47 the generator. This process can be repeated forever forming the digitadition series: 47,58, 71, 79, 95,....Kaprekar called a number which has no generator as a "self-number". He said, "It is self born". 1,3,5,7,9, 20, 31, 42, 53, 64, 75, 86, and 97 are the self-numbers below 100 which cannot be generated by digitadition process. Self-numbers which are primes are called "Self-primes". "Why is a millionaire such an important man ?" asked Kaprekar in one of his books

Numbers fascinated him. Caculations thrilled him.

and answered himself - "...because 10^6 is a self-number".

In 1923, while waiting for a local train at Dombivli station (on the Bombay-Thane line) Kaprekar discovered what he later called "Demlo numbers" after the name of the station. Earlier, he was struck by the common occurrence of numbers such as 165, 2553, 47773, etc, on wagons, motor cars and tickets when he used to travel between Dombivli and Bombay V.T. A Demlo number consists of three parts; the first and the last part of this number when added results in a digit which gets repeated in the middle part. For instance, 79992 is a demlo number because 7 plus 2 is 9; similarly, 588883 is a Demlo number because 5 plus 3 is 8; 247777753 is a demlo number because 24 plus 53 is 77; and so on. A Demlo number is generated by a process which Kaprekar called "Demlofication". In demlofication, one goes on adding numbers diagonally, or in other words, one goes on shifting each successive number one place to the left and then adding them all together. For instance, for the number 351

```
          351
        351
      351
    351
```

389961 where 38 + 61 = 99

In other words, Demlofication is an addition process in which the numbers following the first number are multiplied by increasing powers of 10 (10^1, 10^2, 10^3) before they are added together to produce the demlo number. Similarly, 724 gives 080 444444 364 after nine steps. Zero has been placed on the left of the number to form 080, a three digit number to correspond to 364 on the right. So, any number can be taken and turned into Demlo number by demlofication. "His Demlo mine seems to be inexhaustible and has drawn several gold diggers from distant parts of India to try their luck in his quarry," said one eminent mathematician. Kaprekar also worked out several types of Demlo numbers and gave them colourful names such as Male Demlo number, Wonder Demlo number, Superwonder Demlo number, etc. Besides, he was extremely fond of magic squares involving dates and discovered some curious ones such as "Copernicus Magic Square", "Mahatma Gandhi Shatabdi Square", "Independence Square", etc. He also made several interesting contributions to mathematical magics and puzzles and prepared several models for demonstration.

Kaprekar died in 1988 at Devlali, unsung and unrecognised. He figures as an eminent mathematician only in *The World Directory of Mathematicians* published in Sweden. It is high time somebody should dig into his personal dairies, correspondence and other material which he painstakingly maintained throughout his life. Quite likely, it would throw new light on his work and give new insights into his wonderful mind. □

Brains Trust

Why do warm milk or tea feel hotter if taken after eating pungent preparations or chillies?

Ranitha Das Sabour, (Bihar)

We have four basic tastes:sweet, sour, salt and bitter which respond to taste buds. The different taste buds are located on different parts of the tongue. The buds that respond to the sweet are at the tip of the tongue, while other specializing on salt, sour and bitter are located further back on the tongue. But some of the stronger tastes like 'hot' taste of the spicy food comes about through the stimulation of pain-sensitive nerves ending on the tongue. When we take warm milk or tea after taking some such 'hot' spicy stuff, the beverage feels hotter because the taste buds in the tongue are already sensitized by the spicy food.

Madhu Sahni

PRIZE WINNER

Why does not water come out from a wet cloth unless it is twisted or squeezed?

Ajay Kumar Gaur, Lucknow (U. P.)

Cotton is basically made up of hollow cellulose fibres. If cotton is dipped in water these hollow fibres soak up water by capillary action. As it is held inside the fibres, this water does not come out of wet cotton clothes unless expelled by force.

When we squeeze or wring the clothes, the water filled spaces in the fibres get compressed and thus the water is forced out. On the other hand, synthetic fabrics like nylon or polyester do not have hollow fibres so they don't absorb water. Moreover, the synthetic fibres are hydrophobic, that is, they repulse water. When clothes made of synthetics are dipped in water, water just remains attached to the surface of the fibres. Such fabrics can therefore, just be allowed to drip dry without the need of squeezing or wringing.

Madhu Sahni

Why does ash work as a detergent powder in washing utensils of the kitchen?

Sulabh Saxena, Allahabad (U. P.)

When coal or wood is burnt the ash is produced which contains mainly alkalnic residues and some impurities like silica. These alkaline compounds include carbonates which can be used as cleaning agents. On rubbing the ash on the surface of the utensils, it removes the grease and dirt particles from the utensils. Besides, the gritty silica particles act as a mild abrasive and scrub out sticking dirt, thus helping the cleaning process. Thus ash gives the utensils a shine after washing.

Madhu Sahni

Why does a dead body float on water while a drowning person sinks in it?

K. S. N. Drishna, Tadepalligudem (A. P.)

When a dead body is thrown in water, it sinks first. But after sometime it will come up and start floating on water because after death metabolism stops and decompisition starts. During this process some gases are released and they start accumulating in the cavities of the body and thus body becomes light. It also swells. So the amount of water displaced by the dead body becomes more than the weight of the body and thus it comes up and starts floating on water. On the other hand, a drowning person sinks because the weight of the person is more than the water displaced by it. To keep afloat one has to learn swimming.

Madhu Sahni

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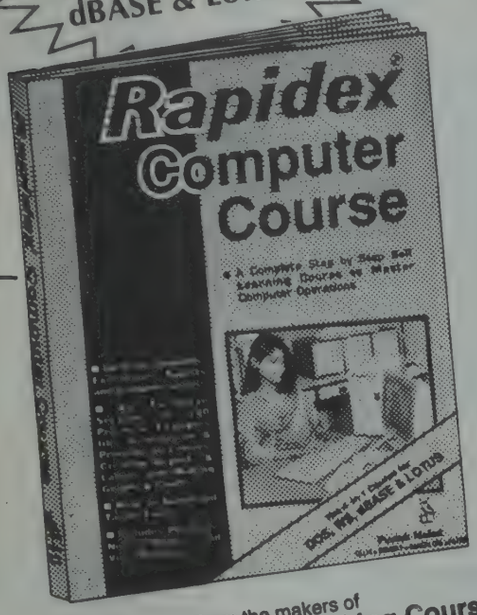

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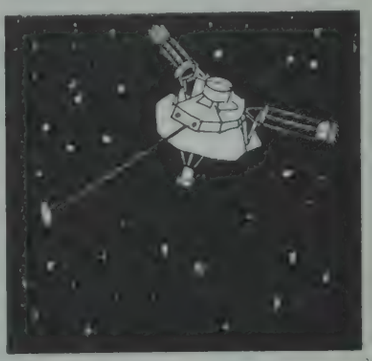
Brains Trust

How can energy be supplied to spacecraft, like *Pioneer II* that go on a long journey lasting several years?

Shankaranarayan V. J.
Badagannur (Karnataka)



All spacecrafts going to distant planets and satellites carry their own packages of energy. These packages are in the form of Radioiosotope Thermoelectric Generators. Heat produced by the decay of a radioactive element (such as plutonium, strontium) is employed to generate electricity from a series of thermocouples (such as lead-tilluride alloy, silicon-germanium alloy). As a radioisotope such as strontium-90 has a half-life of 20 years, these generators continue to generate electricity for long space journeys lasting several years. These generators do not require much shielding as spacecrafts like *Pioneer II* are unmanned missions. However, spacecrafts going to planets such as Mercury or Mars which are near the sun make use of solar cells for the generation of electricity from sunlight.

Dilip M. Salwi

How is it that the hair on the scalp grow long while those on the body do not?

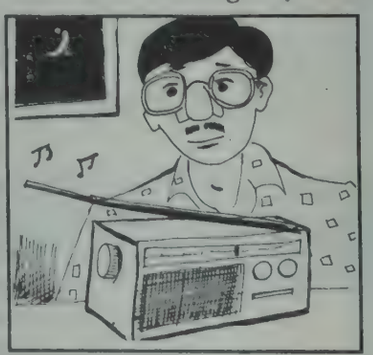
Mithun Bose
Ambernath (Maharashtra)

Over millions of years, man has evolved several distinct traits given the changing environment around him. One such trait is the long hair on his scalp and his almost hairless body. The hair protects the scalp against direct sun and is also believed to enhance sexual attraction. Over millions of years, this evolved trait has become a part of the hereditary system of humans as more and more men with this trait survived in the changing environment vis-a-vis men with hairy bodies. Today, from the stage of conception, human genes, the basic units of heredity, control the growth of hair on the body of humans so that long hair grows only on the scalp and shorter or finer on other parts of the body.

Dilip M. Salwi

Why radio sets do not receive distant stations during day but receive them more readily during night?

Ajay Kumar
Srinagar (J & K)



When a radio station broadcasts radio waves, they travel in two directions. One travels along the ground called "ground wave" and the other goes up into the sky called "sky wave". The medium wave frequencies which are widely used in broadcasting, reach a nearby radio receiver directly through ground waves. However, dry ground conditions and rocky mountains and hills absorb these waves and so they do not reach distant receivers directly. These distant receivers receive these radio waves only after the E and F layers of ionosphere at the heights of 100 km and 220 km above the earth reflect the sky waves back to earth. During the day, radiations coming from the sun forms an ionized layer called the D-layer of ionosphere which lies below the E and F-layers at the height of about 60 km. This ionized layer absorbs and scatters the medium radiowaves, not allowing them to reach the E and F layers and consequently distant radio receivers. During the night, when the D-layer disappears, these radio waves are reflected by the higher E and F layers and reach distant radio receivers. In the case of short wave radio broadcasts, sky waves are the only medium through which the signals travel to distant receivers which receive them only after they are reflected by the ionospheric layers. However, during the day the D-layer absorbs some portion of these waves deteriorating the quality of reception.

Dilip M. Salwi

KOLLEGALA SHARMA

It is tea time

THE drink that cheers is not cheered by all. At least housewives find the scum left behind by a well brewed tea quite a nasty stain. And there is no way to rid the cuppa of doing this too. It is a problem that remains even if you switch the fragrant Darjeeling tea to the *Kharak* assamese or nilgiris. Now, two British scientists have brooded over this brew-problem and have found out the reasons for it. In a correspondence to the British science journal *Nature* (vol 364 No. 6438 pp 381, 1993) Michael Spiro and Deogratius Japanyl reveal that the cause of nuisance is the same polyphenolic compounds which give the cuppa its taste and flavour. The scum is the result of reactions between these compounds and the metal-ions like calcium, magnesium and sodium present in hard water. The reaction produces precipitates which appear as the scum. It contains insoluble organic deposits in which metal salts are embedded.

It is these organic deposits which form the stubborn stains and scum. The metal deposits can be easily dissolved by a dilute acid such as the citric acid from lemon, or dilute hydrochloric acid. But the organic scum does not budge except when a highly alkaline solution is used. Spiro and Japany have found that the longer the tea is left brewing, more is the scum formed. A lemon in the tea not only gives it a refreshing taste but also prevents the scum formation.

Males, And More Males

MALE chaunism, of a biological sort, seems to be dominant in some rodents, especially the gerbils. In a research paper published in *Nature*, John. V. Vandenbergh has reported a strange phenomenon in which the unborn male gerbils influence the future of not only their sisters but also of sisters' offsprings. In rodents which normally sire six to eight young ones at every pregnancy, it is quite common to find some females growing nestled in between two males in their mother's womb. Such females, Vanderbergh says, are more male-like in their behaviour. This, he surmises, is because of the male hormones secreted by their brothers. Such females (called 2MI-females) are also sexually less active, take longer time to mature into puberty and give birth to less offsprings. Not only that, even the sex ratio — the number of females sired in comparison with the number of male offsprings — is offset in these 2MI females because of their unfortunate positioning during their foetal life. Vanderbergh says that 2MI females are more likely to produce more males than females, unlike their fortunate sisters who grow up amongst female fetuses.

Gene Therapy Works

AT last, the idea seems to be right. For quite a few years scientists have been excited over the possibilities of using gene-therapy as a permanent cure for some of the dreadful inhereted diseases. Their idea to remove a malfunctioning gene and replace it with a normal gene although worked to perfection in bacteria and fungi, seemed far-fetched when it came to mammals for the simple reason that the mammalian genetic set-up is very complex. To some extent it could work in the blood cells which roam about freely in the body. However, there were difficulties when a gene had to introduced into a muscle or nerve cells.

It is not so easy to introduce a gene in to the cells in the body of a mammal. But now comes a news from a team of American scientists that the strategy to cure a genetic disease of muscles works, at least in mice.

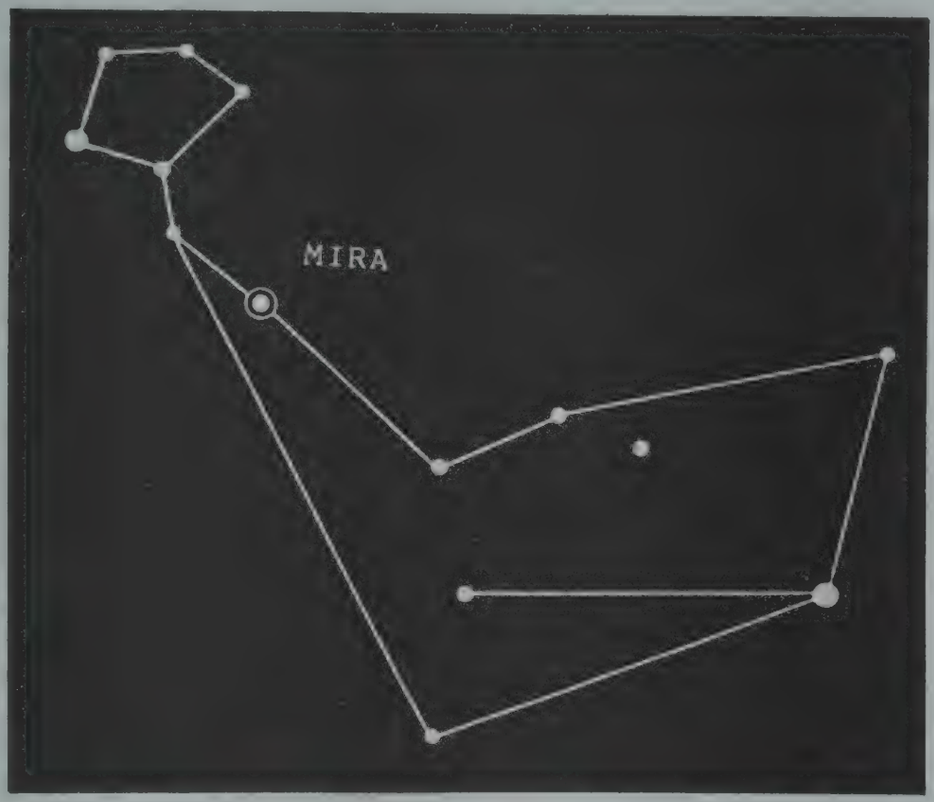
Jeffrey S. Chamberlain and associates at the Human Genome Center, University of Michigan Medical School, Michigan, USA have cured mice of an inherited neuro-muscular disease which is similar to the fatal muscular dystrophy of humans (*Nature*, vol 364 No. 6439, Pp 725-727, 1993). The mice — a mutant strain whose brain and muscle cells lack a gene called 427K — have a very weak diaphragm (the muscular sheet which separates lungs from the body cavity). The diaphragm in these mice slowly degenerate like the muscles of the dystrophy-affected humans. Chamberlain and colleagues injected the DNA containing the 427-K into the zygotes of such mutant mice. They found that the transplanted gene indeed worked and produced necessary proteins that would prevent the diaphragm from growing weak.

STELLA MIRA
The Wonderful Star
(Continued from page 27)

recedes from the earth. As a result the lines in its spectrum are Doppler-shifted toward short wavelengths as the surface approaches us and toward longer wavelengths as the surface recedes.

On the average the periodicity of brightness of Mira is 332 days, so that Mira attains maxima about a month earlier each year. It could happen that the maximum occurs when the star is above the horizon only during day time, which could be the main reason why nobody recognized it as a variable star till the time of Phocylides. Table shows the expected maxima of Mira over the next few years and the local rise time of the star. It appears from the table that we may have had the last chance to get a glimpse of the magnificient star just before the dawn of June 17th 1993. Probably only after 1998, we may be able to get a real favourable condition to observe Mira again! Do not be disappointed if you are still unable to spot the wonderful star. Sometimes, even at maximum, the brightness of Mira does not exceed +5.

We can locate the position of Mira once we recognise the constellation of Cetus. Cetus was seen as a sea monster during Bayer's time as the figure from his "Uranometria" shows. This sea monster fitted very well into the Perseus-Andromeda legend. The principal characters in this Greek myth include the King of Ethiopia (Cepheus), his boastful wife (Cassiopeia), their beautiful daughter (Andromeda), a brave young warrier (Perseus), a winged horse (Pegasus) and the sea monseter (Cetus). According to the legend, Cassiopeia boasted that her daughter's beauty surprassed even that of the sea-nymphs. When Poseidon, the God of the sea heard this, he summoned Cetus, the sea monster, to destroy the coast. It appeared that the anger of the gos could be appeased only by sacrificing Andromeda to Cetus. Andromeda was chained to a rock and Cetus, realizing the prize awaiting him, turned his attention towards Andromeda. Just then, Perseus, the sone of Zeus and Danae was returning after slaying the dreaded Medusa. Perseus unsheathed his sword and leapt from his horse Pegasus in the air to attack. He plunged his sword deep into the monster's neck (probably marked by Miora). Slowly the monster slipped beneath the waves leaving its blood mixed with the foam of the sea. All the major characters in this story are immortalized as constellations in the autumn sky.



The Cetus constellation as a whale

Cetus is now seen as a whale by modern writers. The religious scholars of the seventeenth century saw in Cetus the whale that swallowed Jonah. The arrow formed by the Hyades group of stars in Taurus points roughtly to the "tail" of the whale or the "head" of the sea monster.

Apart from Mira, the most interesting long period variable is Chi Cygni, which is found in the constellation of Cygnus the swan. It is redder and cooler than Mira and seems to be farther away and more luminous. It is a powerful source in the infrared, and if our eyes were sensitive to these wavelengths, Chi Cygni would be one of the brightest stars in the sky. Chi Cygni has a greater range of variation. At maximum it rises to +4 (there are reports that it even reaches a magnitude of +3) and at minimum it drops to below magnitude +14, so that it can be picked up only by a large telescope. It is situated in a line joining the "central" star of Cygnus (gamma Cygnus) and the lovely coloured double Albireo (Beta Cygnus). Chi Cygnus is expected to be at its brightest around 28th May 1994, when it will also be favourably placed for observations. The mean periodicity of Chi Cygnus is 407 days and one can easily compute its successive maxima.

Dr. Mascarenhas is scientist at Millimeterwave Laboratory, Raman Research Institute, Bangalore-560080


NOVEMBER
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URSA MINOR
Polaris
DRACO
CEPHEUS
HERCULES
CASSIOPEIA
PERSEUS
ANDROMEDA
TRIANGULUM
ARIES
PEGASUS
PISCES
CYGNUS
Deneb
Vega
LYRA
AURIGA
Capella
GEMINI
Castor
Pollux
Aldebaran
ORION
Rigel
ERIDANUS
CETUS
AQUARIUS
Fomalhaut
PISCIS AUSTRINUS
CAPRICORNUS
PHOENIX
GRUS
INDUS
Peacock
PAVO
HYDRUS
COLUMBA
SAGITTARIUS
CORONA AUSTRALIS
Altair
AQUILA
EQUATOR
ECLIPTIC
NORTH
SOUTH
EAST
WEST
MAGNITUDES
FIRST
SECOND
THIRD
FOURTH

November

THE diagram shows the evening sky as seen from latitudes 0 to 40 degrees North. The inner circle represents the horizon as seen from latitude 22.5 degrees N. The chart has been extended on the northern and southern sides for use all over India. Beginners wanting to use the chart should hold it overhead and turn it in such a way that the North, South, East and West marked on the chart point to the correct directions. With some experience it would be possible to use it in a more convenient position. With the help of a few known star groups in the sky the remaining stars can be easily identified using the above chart. From a particular place these stars will be seen at about 2130 hrs., 2030 hrs. and 1930 hrs. of local mean time on 1st, 16th, and 30th of the month.

The star meant for a particular day for a given hour can be used for the next day 4 minutes earlier and for the previous day 4 minutes later. For example, if a chart is meant for 8.30 p.m. for 16th it can be used on 17th at 8.26 p.m. and on 15th at 8.34 p.m. In the same way it can be used for other months; for 16th October it will hold good at 10.30 p.m. and for 16th December at 6.30 p.m. and so on.

The stars move from east to west in the sky in their daily motion (due to rotation of the earth) at a rate of 15 degrees per hour. The chart can also be used at other hours in the evenings after taking into account the above shift in position of the stars.

Planetary Positions For November 1993

Date	*1st*		*10th*		*20th*	
Planets	*R.A.*	*Decln.*	*R.A.*	*Decln.*	*R.A.*	*Decln.*
Mercury	15h 07m	19.5S	14h 28m	13.6S	14h 27m	12.0S
Venus	13h 16m	6.4S	13h 58m	10.5S	14h 46m	14.8S
Mars	15h 27m	19.1S	15h 53m	20.6S	16h 24m	22.1S
Jupiter	13h 46m	9.8S	13h 53m	10.4S	14h 01m	11.2S
Saturn	21h 46m	15.1S	21h 46m	15.0S	21h 48m	14.9S

Adopted from figures supplied by Positional Astronomy Centre, Calcutta.

The Moon

THE new moon occurs on 14th at 03.04 a.m. and the full moon occurs on 29th at 12.01 p.m. I.S.T. The moon passes about four degrees south of Jupiter on 12th, four degrees south of Mercury and Venus on 13th, and about seven degrees north of Saturn on 21st. The moon is at perigee or nearest to the earth on 12th and is at apogee or farthest from it on 24th.

The lunar crescent becomes first visible after the new moon day in the evening of 15th.

The Planets

Mercury (*Budha*), is too close to the sun to be visible during the first half of the month. Thereafter it is visible in the morning sky and rises about an hour before sunrise. It is in inferior conjunction with, and transits over the disc of the sun on 6th from about 8.36 a.m. to 10.17 a.m. with least angular distance about 15.5 minutes. It becomes direct on 15th and is in greatest western elongation of about 20 degrees from the sun on 22nd. It is in Libra (*Tula*). Its visual magnitude varies from +2.3 to -o.1.

Venus (*Sukra*), visible in the morning sky, rises about an hour before sunrise during the month. It passes about 4 degrees north of the star Spica (*Chitra*) on 3rd. It passes fron Virgo (*Kanya*) to Scorpius (*Vrischika*) through Libra (*Tula*). Its visual magnitude is about -3.9.

Mars (*Mangala*), becomes too close to the sun to be visible during the month. It is in Scorpius (*Vrischika*). Its visual magnitude is about +1.4.

Jupiter (*Brihaspati*), visible in the morning sky, rises about an hour before sunrise during the first half of the month and about two hours before it during the second half. It is in Libra (*Tula*). Its visual magnitude is about -1.7.

Saturn (*Sani*), visible in the evening sky, sets at about local midnight during the first half of the month and about an hour before it during the second half being in quadrature with the sun on 16th. It moves from Capricornus (*Makara*) to Aquarius (*Kumbha*). Its visual magnitude is about +0.7.

(SOURCE : Positional Astronomy Centre, India Meteorological Department, New Alipore, Calcutta-700 053)

SMART SENSORS

PARVINDER CHAWLA

GOOD news for diabetics! No more traumatic visits to the doctor. No more jabbing of needles in the veins for drawing blood to test for the presence of sugar in it. For, a novel, portable glucose monitor which measures glucose concentration in a single drop of blood in just two minutes is ready for sale. A close check on blood sugar level can be now kept at home itself. The heart of this device is a biochemical technology, a thing known as a'biosensor'.

The dawn of biosensor era is a direct outcome of the confluence of two most powerful technologies of this century — biotechnology and electronics. A biosensor basically comprises a probe which has a biologically derived recognition layer called biolayer. The biolayer is directly connected to a transducer element which converts a biological response — a chemical reaction, may be, — into a response that is further processed and displayed or recorded. This assembly behaves as a single, functional unit.

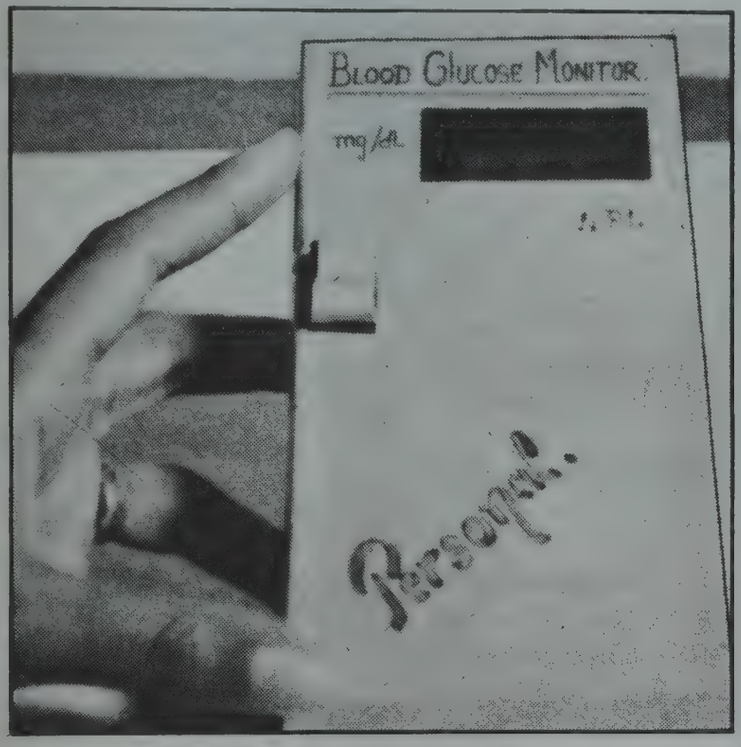
The recognition molecules used in a biolayer range from whole cells, organs, tissues and enzymes to antibodies, hormones, neurotransmitter molecules and even nuclei acids. However, most biosensors have a biolayer made of protein molecules such as enzymes or antibodies whose activity largely depends upon the ionic concentration of the surrounding medium. For creating a stable biolayer, the components of the biolayer are made to adhere firmly or immobilized on the surface of biosensor probe using a wide variety of methods such as physical and chemical attachment, entrapment in a water-loving gel, chemical cross-linking and retention in protective bag-like structures called *microvesicle*s or 'liposomes' and red cell membranes. This biolayer comprising immobilized recognition components, say an enzyme, behaves as an electrode. It directly quantifies a substance, the formation of which is catalyzed by that enzyme. In other words, the operating mechanism of a biosensor involves the enzymic conversion of a specific substrate present in the sample solution to a product to which the transducer element responds. For example, if the biolayer comprises an enzyme called urease, the substrate that it would act on and present in the test sample is 'urea'. The product of this chemical reaction is ammonia the presence of which, causes a change in pH, which is sensed by the transducer. The linking up of the biolayer with the transducer thus enables reagentless analysis as it generates a direct electrical output giving continuous readouts. In this way, the physico-chemical changes which occur due to interaction of biological molecules can be sensed electronically using biosensors.

Biosensors hold an immense potential in fields as diverse as medical diagnosis, agriculture, environmental monitoring and defence. The first-ever biosensor for commercial use was launched in 1987 by Yellow Springs Instruments Company. It was a pocket-sized biosensor for measuring blood glucose. This was a major advance in realizing the promise of biosensor technology. Better versions of blood monitors soon followed. One such device is called I-Stat system. It is a hand-held machine that can be used to analyze six parameters of blood, namely, glucose, urea, nitrogen, sodium, potassium and chloride. However, what has marred the commercial prospects is the cost of this device which is as high as 3000 US dollars.

The development of an indigenous glucose sensor by the Central Electro Chemical Research Institute (CECRI), Karaikudi, bears testimony to the expertise of Indian scientists in this field. The biolayer of this sensor is made of an enzyme called glucose oxidase which is immobilized on the electrode surface. The enzyme catalyzes oxidation of glucose, the substrate, present in the test sample. This sensor is highly sensitive as it gives electrical signals for a glucose concentration as low as 0-15 millimoles (milli = 10^{-3}). Moreover, this sensor shows no appreciable degradation of the enzyme activity after sev-

eral weeks of use. What's more, it has been shown to respond in a normal way for more than 1000 assays. This glucose sensor, integrated with an electrical measurement system forms the glucose monitoring kit.

SO the race is on. A large number of biosensors finding novel uses in various fields would soon reach the public usage stage. These include biosensors capable of monitoring fructose and lactic acid in blood and one that

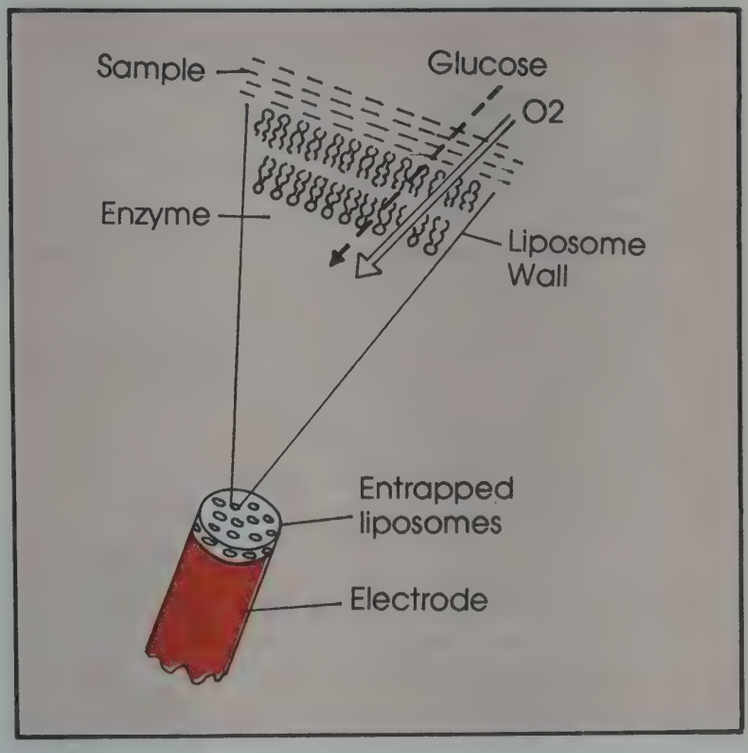


The glucose biosensor developed at National Physical Laboratory, New Delhi

can estimate biological oxygen demand (B.O.D.) in water samples. B.O.D. indicates the level of water pollution. In agriculture, biosensors would revolutionize the detection of viral, bacterial and fungal diseases of crops and livestock. Detection of plant nutrients, fertilizers and pesticides are some other exciting uses which are no more a distant dream.

In medical diagnostics, the biosensor technology is poised to do wonders. It offers an exciting diagnostic tool capable of detecting both infectious and non-infectious diseases. The latter include diseased conditions where certain hormones in the body undergo dramatic alterations. For example, the deficiency of a hormone called thyroxine before birth leads to physically and mentally retarded children known as 'cretins'. An over-production of this hormone in adults increases general body metabolism resulting in a disease called Graves disease. For detecting such hormonal imbalances, the biolayer would consist of special molecules that bind only to that hormone. The bound complexes are then estimated using special techniques. The recognition layer of the biosensors used for detecting infectious diseases would constitute specific antibodies to which the appropriate regions of the pathogen, called the antigen and present in the test sample, can bind selectively. This would help diagnose diseases such as tuberculosis (T.B.)., typhoid, hepatitis and so on, in apparently healthy individuals. That is, at a stage when the pathogen has just entered the human system. Normally, such diseases are difficult to detect in early stages in the absence of specific symptoms. However when in advanced stages they are easily identified but are beyond all curative measures.

The ability of biosensors to detect agents of chemical warfare such as mustard gas and nerve gas shows the promise that these devices have in store for the defence industry as well. This rapidly advancing technology has given way to more sophisticated biosensors which are capable of measuring concentration of specific molecules present in particular regions of the body, without drawing out or removing samples. These 'integrated' biosensors would be able to detect and quantify particular molecules present in inaccessible regions of the body like subcutaneous space or interstitial muscle. Moreover, integrated biosensors would provide faster analysis of substances such as hormones, the level of which fluctuates very rapidly in the body and even substances which easily disintegrate or are highly unstable.



The essentials of a glucose biosensor

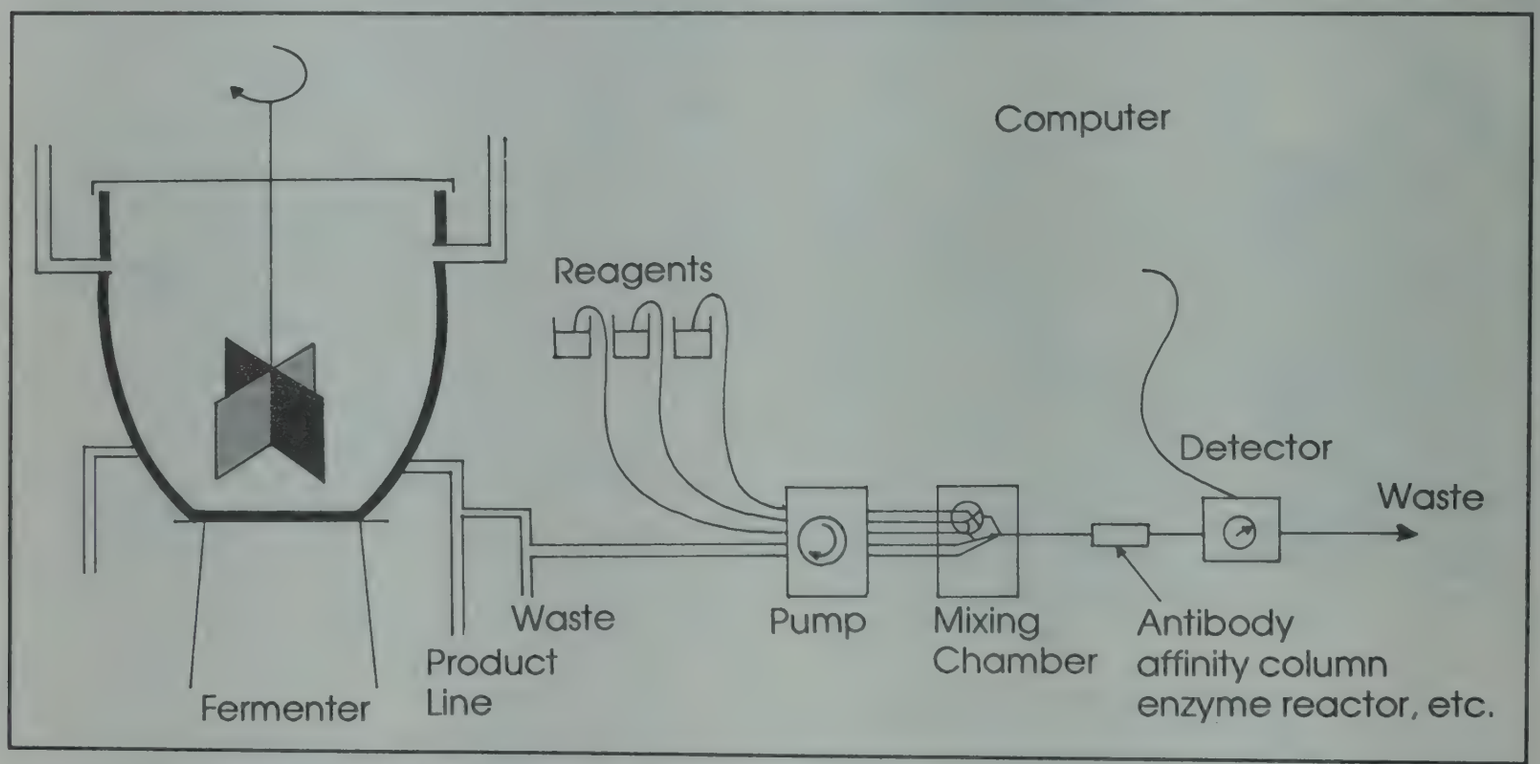
What's more is that miniaturization of biosensors on silicon chips is now in the offing. Sophisticated devices having their components crammed onto a single wafer of silicon are being rapidly designed. Using this technology of fabricating silicon devices, a team of Japanese scientists led by Isao Karube of Tokyo University's Research Centre for Advanced Science & Technology (RCAST) have re-

cently developed an ion-sensitive, Field Effect Transistor (ISFET). This device is highly sensitive to changes in ion concentration and to charge variations. Several ISFET based micro-biosensors have been developed by Karube and his coworkers. This includes a sensor that can measure urea in blood and an alcohol-sensitive ISFET which responds to ethanol and propanol.

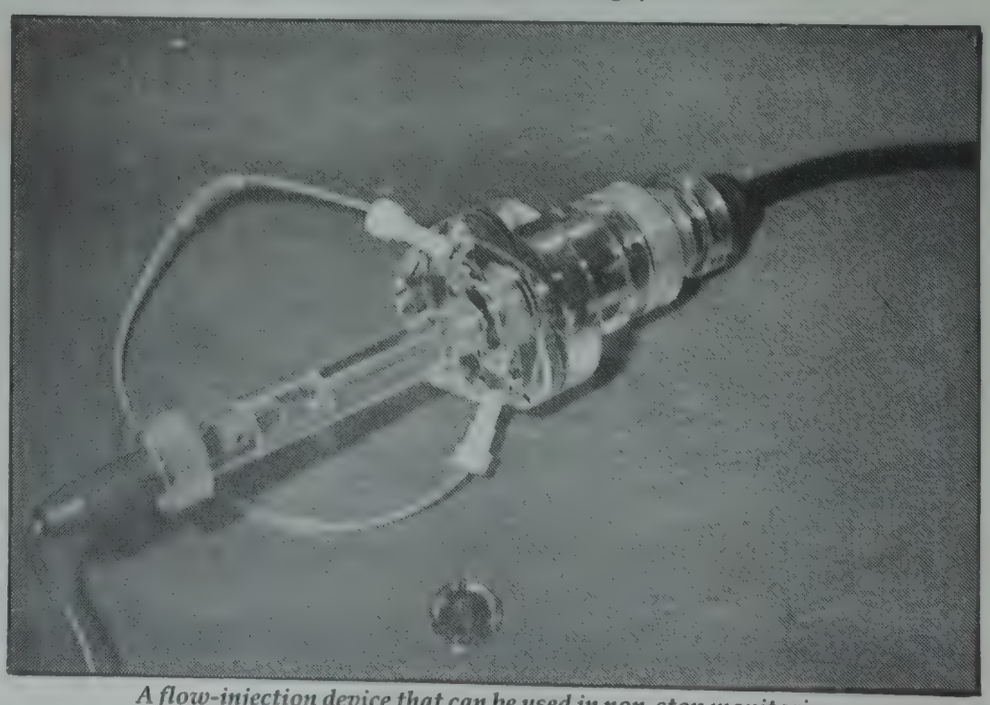
Biosensors are finding a host of novel uses in food industry as well. Using these devices it would be possible to ascertain the odour, freshness and taste of foods, besides the presence of any additives or toxic materials, thus determining the food quality. A biosensor to measure "fish freshness", thanks again to Karube and his team, is now in sight! In this, one of three enzymes, ATPase, aminoxidase or putrescine oxidase is used in determining the freshness of meat. For example, the enzyme ATPase can be used because it acts only on ATP breaking it down. This enzyme can detect the presence of ATP in fish muscle. The reaction between ATP and ATPase is converted by the biosensor into a recognizable signal. If ATP is not present, as in stale food, this signal would not occur. This sensor can thus alert consumers when a meat product is no longer fresh.

Yet another biosensor that detects contaminants in food materials has also been made. Prof. Simon of Swiss Federal Institute of Technology, Switzerland has constructed a simple sensor for measuring 'nitrate', a very common pollutant found in vegetables. In this sensor, the nitrate passes through an ion-selective membrane. This changes the colour of a pH indicator which is instantly detected by the transducer.

Novel biosensors for analyzing various individual food components are also on the horizon. One such biosensor, thanks to Prof. Turner and coworkers of the Cranfield



Biosensors can also be used for monitoring continuously the changes in a fermenter. A design for the same



A flow-injection device that can be used in non-stop monitoring

Electronic Sense

THE essence of biosensor technology is the linking up of a recognition layer with a transducer element The latter forms an essential part of this sensing device for, without it, the unrecognizable biochemical signals from the biolayer cannot be processed and displayed. The base material of the transducer could be either metallic or simplly organic in nature. However, broadly a transducer could be classified into four types. One, electrochemical transducer which could either measure the amount of current flowing at constant potential (amperometric) or measure the changes in electrical potential (potentiometric) or one that can measure changes of conductivity between two electrodes (conductimetric). Second is the optical transducer which could measure changes in optical properties. Calorimetric or thermal transducers are the third type which could measure small changes in temperature. These transducers are useful in monitoring the enzyme-catalyzed reactions like fermentation which generate a considerable amount of heat. Finally, acoustic transducers are those which could measure changes in the acoustic properties of the sensor.

Majority of commercial biosensors have amperometric transducers. Some potentiometric transducers commonly used are ion-selective electrodes, gas-sensing electrodes and field-effect transistors (FETs). Ion-selective electrode are well established for use in areas such as water-monitoring. Recently, transducer devices incorporating both amperometric and potentiometric sensors have been fabricated on silicon base and mounted on a suitable plastic support. Conductimetric transducers are also being routinely used for ascertaining the salinity of marine environment.

Although the choice of a transducer element depends upon the particular use of the biosensor, the other factors which attribute to its selection are, the ease of its fabrication, ability to be miniaturized, physical robustness and stability in responding to a given stimuli.

Institute of Technology, U.K. measures the level of cholesterol in butter and margarines. This has the enzyme cholesterol oxidase which reacts with cholesterol, immobilized on the electrode. It makes the measurement of even the minutest amount of cholesterol in the food (1-10 milli moles) simple and fast.

Nothwithstanding the plethora of uses of biosensors in food industry, it is not without its limitations. This is so because all food processing equipment have to be sterilized before using as any contamination may render the food products unfit for human consumption. However, sterilization procedures which kill all bacteria and harmful germs pose a serious problem while sterilizing the biosensors among other food processing equipment. For example, if the biolayer is represented by a complete body organ, then its tissue architecture should be intact. In case it is a tissue, it would require adequate nutrients and oxygen supply for maintaining its structural integrity. Therefore, the biological nature of the recognition elements of a biosensor are inherently sensitive to the harsh conditions subjected to, during sterilization. The biolayer is especially highly vulnerable to lose its effectivenss at extremely high temperature used for sterilization. For using biosensors in industrial processes that are carried out in completely sterile environments, such as microbial cultivation for the production of beer (in a process called fermentation), a new technique referred to as "flow-injection" analysis, has been developed. It involves the removal of samples, during a processing operation, under sterile conditions. The appropriate analyte is then measured using a biosensor. Using this system, Dr.T. Schepen and his colleagues of University of Hannover, FRG, have constructed a special resistor (thermistor) whose action depends upon changes in its resistance material which occurs with corresponding changes in temperature. Using this one can continuously monitor the temperature changes that occur during a fermentation process. To add to the exciting uses of this technology, in Japan, a flow-injection analysis system has been developed for taste-sensing which is finding extensive use in the manufacture of soups!

Triumphantly making its mark in almost all fields of consumer interest, the biosensor-technology has even had its way in sports. A biosensor which can measure the levels of lactic acid and ammonia in perspiration is soon coming up. As it would help in determining fatigue, the sportsmen especially athletes would be benefitted considerably.

With its immense uses in several industries, biosensors are today hailed as the solution to many analytical problems. Consequently, the domestic market for this technology is gradually on the rise in various countries. Japan, the country leading the whole world in biosensor research and development has several companies which at present are engaged in developing biosensors for a host of novel uses. Nevertheless, for a technology so widely explored, the biosensor products ready for public usage are rather few. This is largely because of the high cost of manufacture of biosensors.

However, the current advances made in biosensor technology assure that the day is not far when the image of biosensors as a miniaturized probe or a hand-held box which was hitherto a science fiction, would turn into a stark reality.

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SANTIMAY CHATTERJEE

SAHA—The Man and His Message

MEGHNAD Saha emerged on the international science scene in 1920 when he was only 27, and had the rare distinction of being elected a fellow of the Royal Society at the age of 34. Along with scientific excellence he displayed a tremendous zest for work which spurred him on to involvement in a much larger field. To understand his motivation and philosophy a brief outline of his career is the first step.

Meghnad Saha was born on October 6, 1893, in the small village of Seoratali, forty-five kilometers from Dacca, now the capital of Bangladesh. There was no tradition of learning in the family; in fact his father, a small trader was hostile to the idea of sending his son to school. From his early childhood Meghnad had to fight to get his dues. However, through the efforts of his elder brother and some teachers of the village school he could carry on.

He completed his school education by winning merit scholarships. He passed B.Sc. in 1913 and M.Sc. in 1915 in mixed mathematics from Presidency College, Calcutta. He joined Calcutta University as a lecturer in 1916. Along with post-graduate teaching he continued to do research. His first paper on 'Maxwell's stresses' was published in the *Philosophical Magazine* in 1917. This was followed by a series of papers. Early in 1920 he communicated the famous paper 'On the Ionization of the Solar Chromosphere'. This paper incorporated the theory of thermal ionization. It was followed by three other papers entitled 'On Elements in the Sun', 'On the Problems of Temperature Radiation of Gases' and 'The Harvard Classification of the Stellar Spectra'.

The Premchand Roychand Scholarship and the Ghosh Travelling Fellowship enabled Saha to go to Europe in 1920. He worked with Professor A. Fowler in London and with eminent workers in various fields. When he was with Professor Fowler he rewrote his paper on 'The Harvard Classification of Stellar Spectra' and this was published in the *Proceedings of the Royal Society* in 1921 under the title 'On a Physical Theory of Stellar Spectra'. This paper and the one 'On the Ionization of the Solar Chromosphere' are the most significant of Saha's many scientific contributions. Saha's theory made quite an impact and initiated a considerable amount of work in the field. The original theory was later improved by other stalwarts like R.H. Fowler, E.O. Milne, as well as by Saha and his students. Now other physical properties of the stellar spectra like temperature, pressure, etc. could be predicted. The theory also found application in numerous other problems like conductivity of flames, electric arcs, explosion phenomenon, the study of ionosphere, and hot plasma. Seventy years after its first formulation, as stellar temperatures are being produced in the laboratories in attempts to control thermonuclear energy, Saha's theory continues to be useful in understanding the magnetohydrodynamic processes. Before leaving England at the suggestion of Prof. H.H. Turner of Oxford, Saha wrote to Dr. G.H. Hale, Director of the Mount Wilson Observatory, hoping to have access to the mass of data already present there and added a list of his predictions which could be verified. Because of financial constraints Saha could not go there, but Henry Russell and his co-workers worked along the lines indicated by him and proved his predictions to be right. Unfortunately 'Saha was not invited to the party', as pointed out by Russell's biographer.

'He was convinced that industrialisation was the only alternative open to us'

In November 1921, Saha was called back by Sir Asutosh Mukerjee to join the Calcutta University as the Khaira Professor of Physics. However, he soon left Calcutta to join the Allahabad

University as Professor and Head of the Physics Department. When Saha arrived at Allahabad it was just a teaching institution. He reorganised the physics department, and started research in various branches of physics. He had the good fortune of having brilliant men like P.K. Kichlu, D.S. Kothari, K. Majumdar, G.R. Toshniwal, R.C. Majumdar and many others as his students during his stay at Allahabad. He could thus slowly expand the research studies in other fields such as atomic and molecular physics, application of the theory of thermal ionisation on problems of astrophysics, active nitrogen, high temperature dissociation of molecules, statistical mechanics, propagation of radiowaves in the ionosphere and physics of the upper atmosphere, etc. Trained primarily as a theoretical physicist, Saha always emphasised the importance of experimental work and took a great deal of interest in it. In 1926 Saha became the President of the Physics and Mathematics Section of the Indian Science Congress held at Bombay. In 1927 he was elected a Fellow of the Royal Society of London. It was recently mentioned in an international seminar held at the Saha Institute, Calcutta that Saha's election to the Royal Society was delayed by two years by eminent British physicists on the ground that British Intelligence report had branded Saha as a 'rabid revolutionary'.

The Allahabad School soon earned international recognition. But apart from bringing up his students Saha was using his stay at Allahabad in equipping himself with knowledge of diverse subjects like Hindu scriptures, Ancient Indian History and architecture and Sanskrit. The Allahabad faculty had very learned scholars on these subjects, particularly Prof K. Chattopadhyay with whom Saha was on very friendly terms. They met almost daily and discussed problems in Ancient Indian History and Archaeology. Saha took Prof. Chattopadhyay and Prof. D. Kaushambi of the Aligarh University to archaeological site of the ancient city of Kaushambi. His interest led to excavation work there with astounding results.

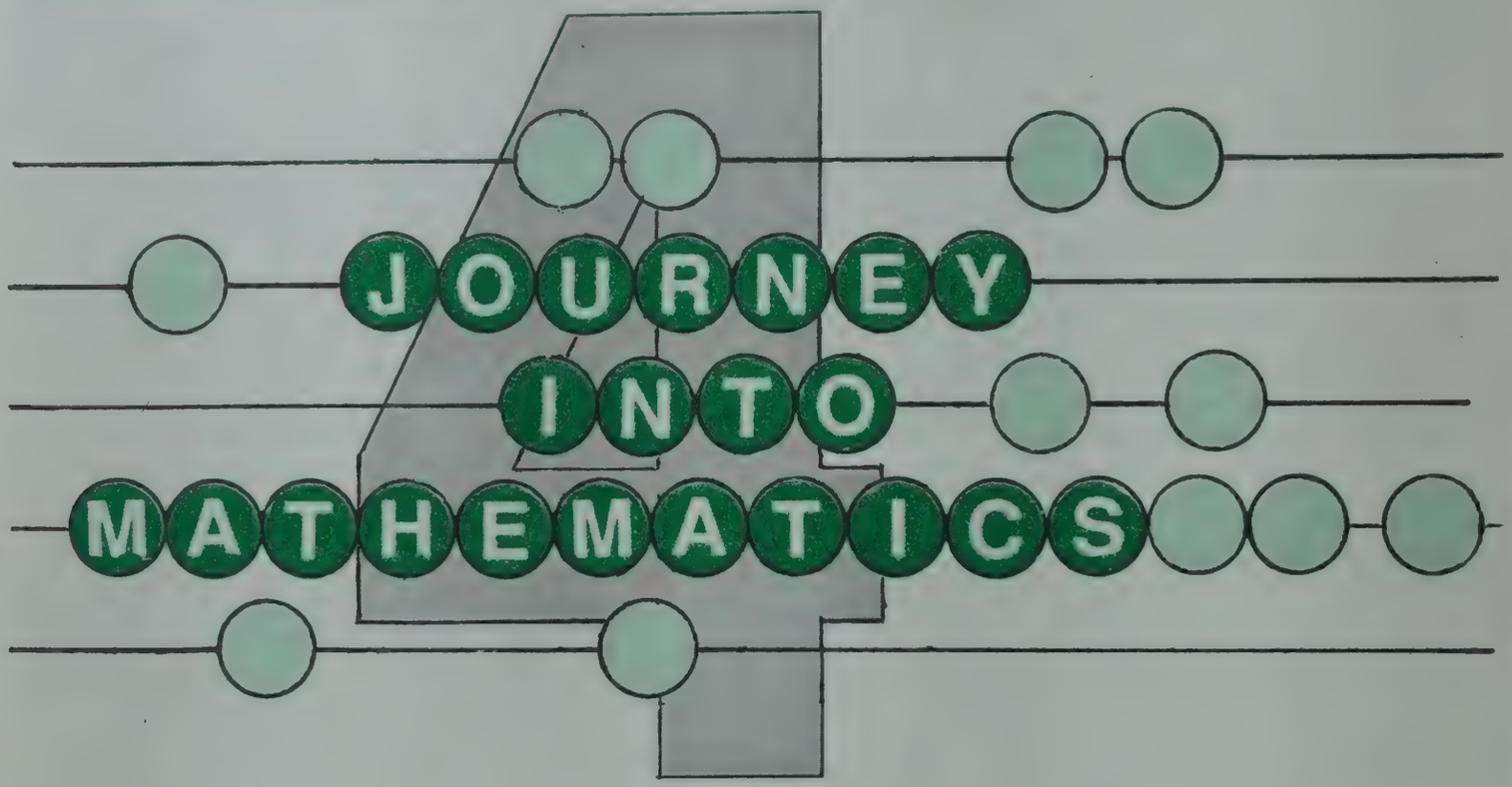
From 1930 onwards Saha slowly turned his attention to other social and national problems. The first step in this direction was the foundation of the U.P. Academy of Sciences, later renamed as National Academy of Sciences, at Allahabad, which completed sixty years of service in 1990. In 1934, as the General President of the Indian Science Congress he made a strong plea for the foundation of an All India Academy of Science. This led to the establishment of the National Institute of Science (now called Indian National Science Academy).

'All men of his generation were inspired by nationalism, but Saha's view was that of a pragmatist'

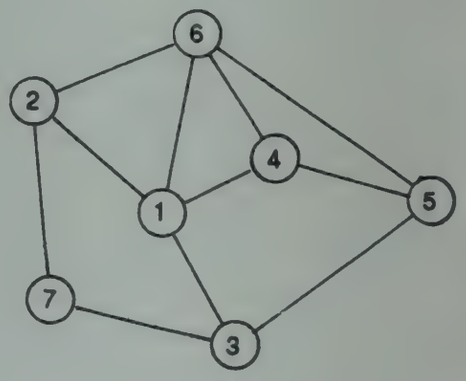
It was during this time that Saha stepped out of the academic ivory tower and began seriously to think of the involvement of the scientists in the economic reconstruction of the country. Already he was convinced that industrialisation was the only alternative open to us. With the launching of the journal *Science and Culture* he began to present plans for the future. He wrote extensively and induced other experts to write on all aspects of economic planning. He laid special emphasis on river control because since his childhood he was familiar with the devastation caused by floods.

In 1938 he came back to Calcutta and plunged headlong into hectic activities both inside and outside the laboratory. He was instrumental in the formation of the National Planning Committee. His reorganisation of the Physics department, the Indian Association for the Cultivation of Science, and founding of the Institute of Nuclear Physics is well known. He also played an important role in the formation of the Central Glass and Ceramic Research Institute. Behind all his activities was a desire to apply scientific knowledge to the benefit of the common people. All men of his generation were inspired by nationalism, but Saha's view was that of a pragmatist. He always insisted that the ultimate aim is not to drive away the British — that was only the first step. We have to educate the people, develop a respect for science and train them to derive the maximum from nature. He believed that the success of the western people is the result of their victory over nature. He wanted the same to happen here and carried on a life-long crusade to bring this about. His entering politics was a part of this mission because he wanted his voice to be heard — the voice of constructive criticism.

Professor Chatterjee is a biographer of Saha. Address: 164/78, Lake Gardens, Calcutta - 700 045



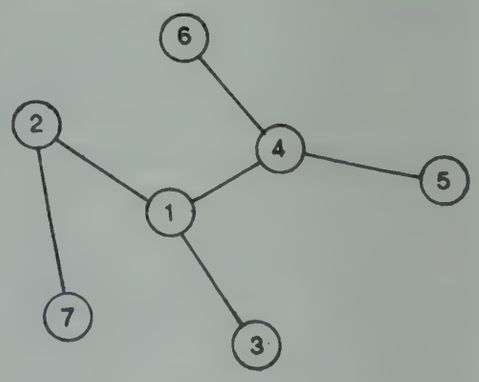
CLIMBING TREES



"Trees ! Ha, that too in Mathematics. Eh ! you must be joking". Well, that must be the response of most who associate only the puzzling mazes with mathematics imagery and not trees. But trees, of course of a different sort than the green ones, are a part of modern maths. Trees, infact, are the other sort of graphs and a very common way of making things clear in a mathematics like the saying that all Xs can be Ys but not all Ys can be Xs. Similarly, all the trees can be graphs but not all graphs can be trees. In fact, a tree is simply a connected graph with no cycles. But then, you might be wondering that how can a Banyan tree sketched on a paper looks like a connected graph with number of cycles, be a tree. Banyan tree may not be a cyclic graph, yet it can be a sort of graph called the spanning tree.

A spanning tree is a special type of connected graph whose vertex is the same as the vertex of a the given graph, but whose edges are only a subset of the edges of the graph. This type of tree is, in fact, the basic element of trees in Discrete Mathematics. Let's consider the following graph, which is definitely not a tree.

The spanning tree in this graph would therefore be :



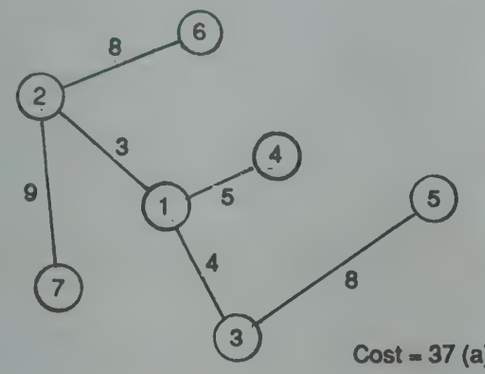
But how did we get this ? Yep! That's not any an interesting and intriguing mystery. It becomes simple if you follow the rules of spanning tree or the algorithm.

First, pick any vertex, and include it in the tree. Do so for other vertices also. If all the vertices are in the tree, then stop. Otherwise find the vertex which isn't in the tree yet, but which is connected by an edge to any vertex already in the tree. Add this vertex and the edge to the tree. Keep doing so till all the vertices are in the tree.

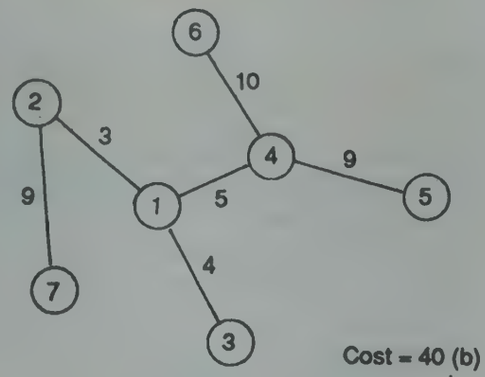
Well! All of this seems to be just a drawing excise, isn't it ? What good can come of it ? Spanning trees are indeed important in our every day life.

Lets consider the previous graph and for convenience we attach a number to each edge. We could think of the seven vertices as seven towns located in a remote wilderness. The number on the edges is the costs in lakhs of rupees of building direct communications links between the given pairs of towns. The fact that there is no edge between the towns 1 and 5, for example, means that the cost of building a direct link between them is prohibitive, that is effectively infinite. It is of practical importance to know how to connect all these cities together with a communications network as cheaply as possible. To do this, we should build a communications network consisting of a subset of the edges in the present graph which forms a spanning tree. Why a spanning tree ? Because if the graph that we build isn't connected, the cities won't be able to communicate to each other; and if it has a cycle, we can remove an edge thereby saving money. The towns on the graph however will still be connected.

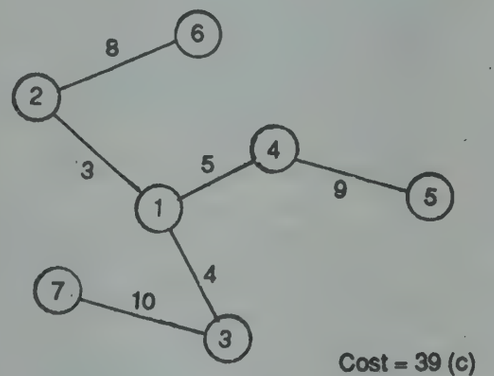
A given graph, however, can have many spanning trees. for example the above graph can have three spanning trees. Now, which spanning tree links up all the towns but saves on the cost is the question before us. The cost of a tree can be calculated by simply adding together the number on its edges or the cost of edges. Now, of



Cost = 37 (a)



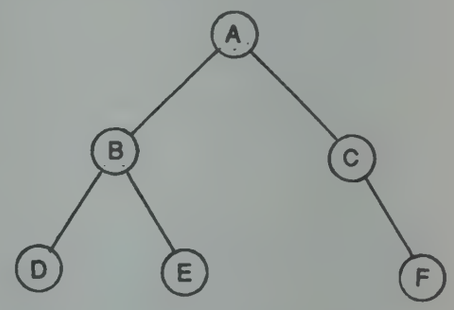
Cost = 40 (b)

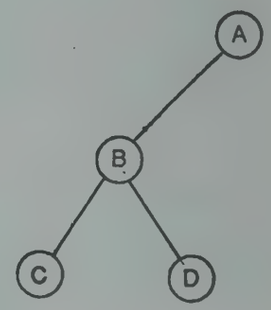


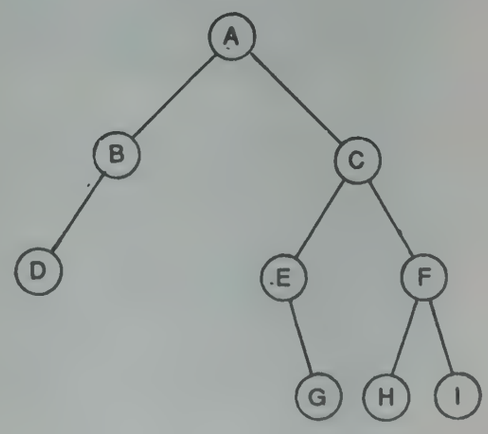
Cost = 39 (c)

these three spanning trees the first one (a) has the lowest cost. But then, there are many other spanning trees - is there a cheaper one ? This question is a special case of what is called the problem of *minimal-cost spanning tree* (MST). It was in 1956 that this problem was solved by Robert C.Prim, an American mathematician who discovered the *Prim's Algorithm* at the famous Bell Laboratories. His help was sought by the world known AT&T group trying to mechanize private telephone line tolling. The prim's algorithm begins by assigning vertices to a tree and follows it by a check to see if all the vertices are there in the tree. If yes then the process stops. Otherwise the cheapest new vertex is added to it. It continues till all the vertices are used up. Although prim's algorithm, gives a definite solution it is timke consuming and requires a lot of memory on the computer.

BINARY trees are another important type of trees. As it is clear from its name, Binary stands for something pertaining to two. It is indeed a tree with a root and two branches which in turn are popularly known as the left-child and right-child. Precisely a binary tree is either empty or consists of a root and two disjoint binary trees, called the *left subtree* and the *right subtree*.

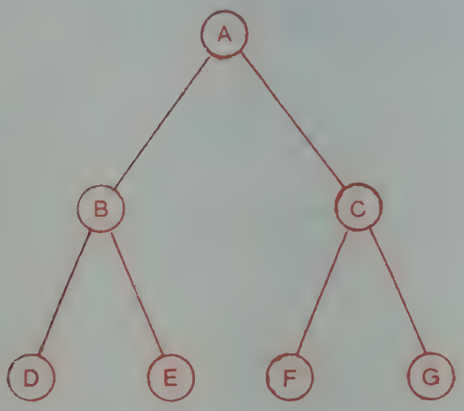






The Root is the vertex on the top and the left-child or left-subtree is the descending left vertex and right-child

or the right-subtree the descending right vertex. Binary trees are at times not only used to solve lot many computer science text problem but also to solve problems in daily life like understanding a family-tree or the hierarchies in a office and so on. But for that, it is necessary to 'search' a binary tree. That is, to travel through the tree visiting the vertices one at a time. Since the vertices in a tree are not arranged linearly, it may be difficult to decide in which order the vertices should be visited. For example let us consider the tree. Assuming that we



start at the root A, in which order should we visit the vertices? One natural answer is, of course, the alphabtical order A,B,C,D,E,F,G, but on second thoughts this ordering does not seem natural after all. It requires jumps between vertices that aren't connected by an edge for example, B to C, D to E and so on.

We now again need a set of instructions to search out a suitable tree. There are large number of such algorithms of which the three famous ones are the preorder, postorder and inorder search.

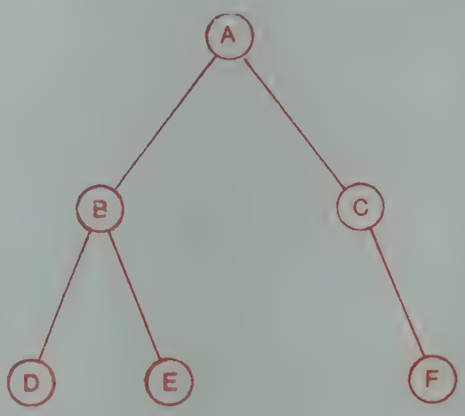
Preorder search amongst the three is considered to be most useful tree searching algorithm. It involves the following steps.

1. Visit the root
2. Visit the left-subtree, using preorder
3. Visit the right subtree, using preorder.

'Using preorder' clearly shows that the definition of preorder, like that of a binary tree, is recussive. In simpler words it means that the vertices of the tree will be visited in the order

A, [A's left subtree], [A's right subtree].

For example consider the follow-

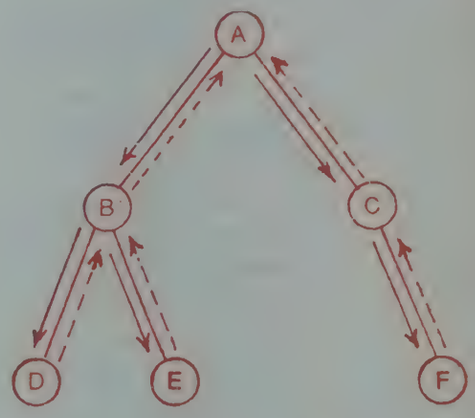


ing tree. Continuous arrows here represent the preorder traversal. Thus the preorder tree search in the present case would be ABDECF. Preorder search is also at times called as the depth-first search. Well, there is another way to describe this sort of search. According to it we start from the root and at each successive vertex, do the following.

Step 1 : Go left, if possible; if not, go to step 2
Step 2 : Go right, if possible; if not, go to step 3
Step 3 : Back up, if possible, if not, go to step 4
Step 4 : Halt.

This type of tree traversal is called backtracking which is indicated by dotted arrows.

Besides preorder search there are several other tree searching algorithms which are occasionally useful. The most common of them are called as postorder and inorder. Both these algorithms are very much like preorder and are defined recursively. The post-ordering sequence of search of the vertices for the above example would be [A's left subtree], [A's right subtree], A. Thus in the above example the post-order search for the tree would be D,E,B,F,C,A. Post-order is also important largely because of its relationship to *reverse Polish notation* (RPN), which is used to manipulate algebraic expressions in many pocket-calculators, and in the FORTH programming language. Last, but not the least, of these common tree traversal techniques is the inorder search



according to which first the left subtree is visited, then the root followed by the right sub-tree. In the example of the tree we've been considering so far, the inorder output would be DBEACF.

Data structures are an integral part of core computer science and since Discrete Mathematics is maths of the computers, Data structures and alogrithm analysis ought to encompass the elements of it. Trees are in fact the firm bases that utilize concept of stack or space where entering or pushing and deleting or popping functions materialize. But before we part for our next halt let us not forget trees are basically graphs which are better defined in terms of the famous Daisy chain theorem -

"Let T be a graph with n vertices. the following six statements about T are equivalent, that is either T has all six of the properties, or none of them.

(a) T is a tree
(b) T has no cycles and n-1 edges.
(c) T is connected and has n-1 edges.
(d) T is connected; but removing any edge disconnects it.
(e) There exists exactly one path between any two vertices.
(f) T has no cycles; but connecting two vertices with an edge will create a cycle."

(To be concluded)

Sh. Parashar is Scientist in Publications & Information Directorate, New Delhi

SCIENCE ON STAMPS

World Exhibition 'Expo - 92'

KABITA ROY

POSTAGE stamps are passports for different types of articles that can be sent to any part of the world. But today, these little passports are shouldering extra and heavier responsibilities. For instance, they are increasingly being used as a medium for various types of campaigns. The stamps shown here depict 'EXPO-92', a world exhibition that was held in Seville, Spain from 20 April 1992 to 12 October 1992.

Since 1945 world exhibitions have been held in Brussels (1958), Montreal (1967) and Osaka (1970). Expo-92 was the largest exhibition of all time and devoted special attention to the discovery of America by Columbus in 1492. One hundred and ten countries and a number of major industries participated.

Being the host country, Spain released a number of stamps. The latest stamp design depicts the whole architectural setting of the new Pavilion — two hectares of constructed area divided into three levels in an original project, striking for its hemispherical dome housing a unique projection hall in which images are combined with moving, computer-synchronized seats; a cubic white marble building inside which a permanent exhibition of masterpieces of Spanish art can be contemplated.

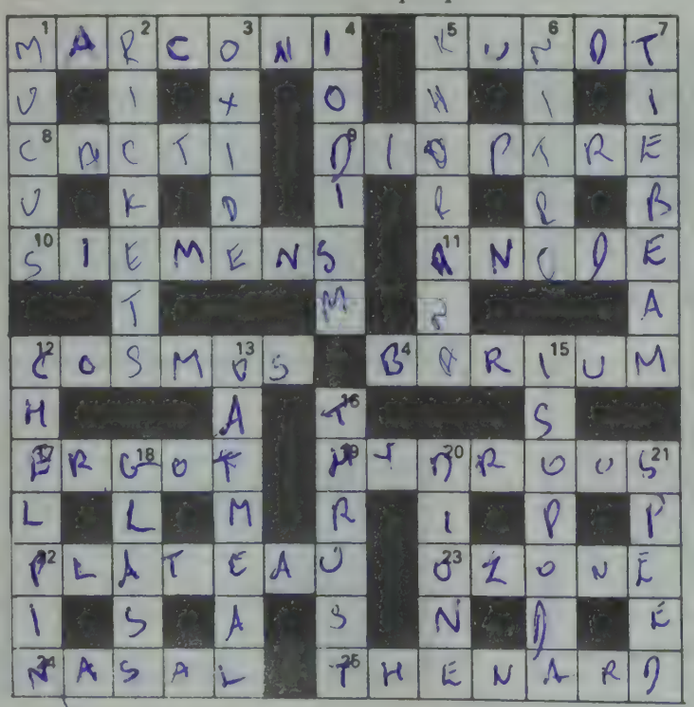
The Netherlands, Finland, Phillipines, Fiji, Kiribati and a host of other countries brought out stamps on this occasion.

CROSSWORD

VIJAYA KHANDURIE

ACROSS

1. Guglielmo _____: Pioneer of wireless telegraphy (7)
5. _____'s tube : A glass tube in which standing waves are produced whereby sound velocities are measured (5)
8. Plants growing in hot dry regions, with thick fleshy stems but no leaves (5)
9. A measure of lens power (7)
10. Reciprocal of ohm (7)
11. _____dark space : Dark zone near the positive terminal of a discharge tube when it is glowing (5)
12. A series of Russian multipurpose satellites (6)



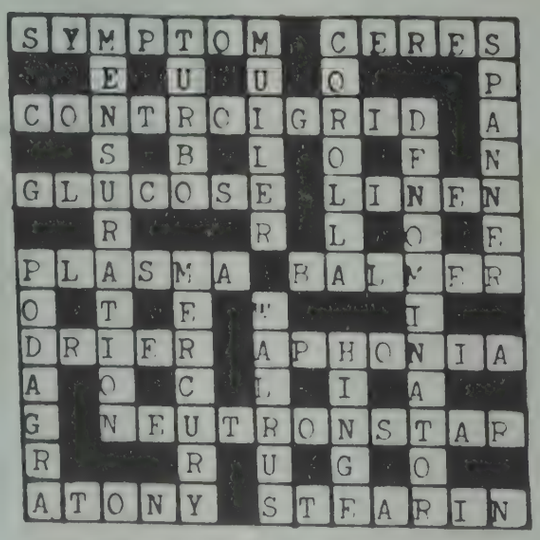
14. An alkaline earth metal in the second group of the Periodic Table (6)
17. The dried sclerotium of the fungus *Claviceps purpurea*, which grows on rye plants (5)
19. Containing water (7)
22. _____length : The range of voltage corresponding to the plateau of a Geiger counter tube (7)
23. A powerful oxidizing agent (5)
24. Pertaining to the nose (5)25. Louis Jacques _____, a French scientist who discovered hydrogen peroxide (7)

DOWN

1. Viscous fluid containing muco-protein (5)
2. A condition marked by distortion of bones. A result of vitamin D deficiency (7)
3. A compound of oxygen with another element (5)
4. Iodine poisoning (6)
5. Surname of the India-born US scientist who shared the Nobel Prize with Holley and Nirenberg for studying genetic code (7)
6. _____benzene: $C_6H_5NO_2$, a liquid that smells like bitter almonds (5)
7. A beam which prevents the spreading out of the lower ends of the rafters of roof trusses (3,4)
12. Sir Arthur Harden of England and Hans Euler_____of Sweden were the winners of 1929 Nobel Prize for chemistry. They were awarded this prize for research on fermentation of sugars (7)
13. Meal made from crushed oats (7)
15. Order of Malacostraca (7)
16. Propulsive force developed by a rocket-motor (6)
18. An amorphous, hard, brittle superfluid substance whose melting point varies between 800°C and 950°C (5)
20. Heavily cratered satellite of Saturn (5)
21. A measure of the light transmitting power of a lens stated as its f-number (5)

(Solution in the next issue)

Solution to September Crossword



Shri Khandurie is a science educationist. Address : 23-L, Sector IV, D.I.Z. Area, Shahid Bhagat Singh Marg, New Delhi-110001

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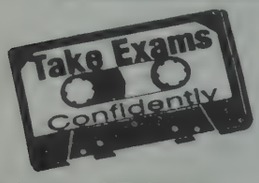

Relax and Take Exams Confidently without Stress or Nervousness

(Code 140)

This is useful for anyone who is nervous in exams. For anyone who can not write in exams what he knows. For anyone who forgets in exam hall, but remembers immediately after the exam.

This cassette helps you get the maximum benefit in the exam hall from your preparation and hard work.

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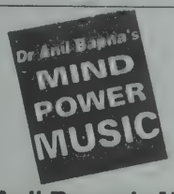
This cassette programs you with strong will power. It helps you continue to try to achieve your aim/goals even in the time of difficulty.



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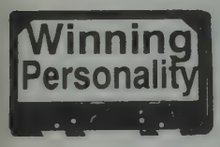
- Very good. It relaxes my body and my mind. It reduces the tension of my studies.
  —Dr Anju Banthiya, MBBS, Bhopal, M.P.
- With your music, I start reading with more efficiency and more concentration. *—Tarun, Haryana*
- Your music improved my concentration. Now my mind works faster. *—Shaikh M-Faiyaz Faridmiya, Gujrat*
- Your music is very effective.
  —A. V. S. Satish, class XII student
- IIn two days, I have reduced my daily cigarette smoking by 10-15%. *—Cecil Chacko, Bombay*
- Dr Anil Bapna's research to increase the effectiveness of the mind by using music is appreciable..
  —Rajasthan Patrika Book/Music Review



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180	Setting and Achieving Goals
190	Prosperity Thinking for More Wealth
200	Achieve Peace and Happiness
210	Effective Public Speaking
220	Enjoy Exercises for Good Health
230	Gain Self-Confidence
240	Read Faster to Save Time
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Tuning In To The WILD

Finding out how animals in the wild behave and where they spend their time has become an easy job with the advent of radio tracking, says *BIPUL CHAKRABARTY*

FOR millenia men have struggled to make out some meaning of the tracks and signs left behind by other animals. With his ingenuity early man could track down animals in the wild using fecal pellets and footprints as clues. But then, man graduated from being merely a hunter to a scientist who was more interested in how the animals behaved, where they took shelter and how they carried on with other life activities. And all this not because he wanted to hunt the animals down but only to ensure that they did not run the risk of extinction.

For this, man needed more definite ways of locating animals in the wild.

For, after all, a gust of wind could easily erase a line of tracks. In the early 1960s, William Cochran and R. Lord working at the Cedar Creek Field Station in Minnesota, U.S.A. published for the first time an electronic circuit that could be used to track down wild animals. This was the beginning of radio tracking which has never looked back since. It has now become very easy to find out not only where animals spend their time but also with whom they do it. Even the very rare and extremely shy Snow Leopard found in the Kashmir Himalayas could be tracked by a team of biologists once a radio collar was fitted on the animal.

Radio tracking has now transformed biological field studies and promises to provide answers to a host of outstanding biological questions. In practical terms, radio tracking and biotelemetry involve fitting a miniature transmitter to the subject using a collar, or a harness, or perhaps by implantation inside the animal's body. The miniature transmitter emits a signal commonly of very high frequency or VHF(>100MHz) and often in pulses via an antenna which may be a loop around the neck serving also as a collar, a whip (a straight wire) or a coil of copper wire around a ferrite rod. A receiving antenna picks up the signals at a range of several kilometres. Then a beat frequency oscillator(BFO) translates the received signal. The signal is converted by a demodulator (a black-box) which changes output of the receiver into a form appropriate for direct computer processing, storage on tape, or visual display. Some receiving antennas are directional — the strength of their signals (the volume of the perceived beep) is at a maximum when the antenna points at the incoming beam of radio waves. Thus the biologist can tell the direction of the signal by its volume; and in principle, using triangulation he should be able to pin-point his animal's position or in the jargon, to 'take a fix on it'.

Triangulation is a technique through which an animal's location is judged through radiotracking. A set of three compass bearings are taken on the animal from three different

The radiocollar continuously transmits messages

locations (which is judged by the maximum frequency received by the headphone) and then they are plotted on a map of the area. The lines intersecting form a triangle which approximately gives the location of the animal at a particular point of time. On visiting the area the activity of the animal could be judged by the signs left by the animal.

However the biologist is cursed by the topography. The direction from which he receives the signal is not necessarily the same as that from which it left the animal because radio signals bounce along the sides of valleys, ricochet off rock faces, filter between detached houses and become polarized by stands of vegetation. These would lead the "textbook" tracker or the inexperienced in pursuit of spurious fixes.

People who fail to check their triangulations while still in the field may sometimes find, when the time for analysis comes, that the homerange of their strictly terrestrial animal encompasses substantial areas of the ocean! The tracker must remain a 'fieldman' knowing every detail of the landscape and its idiosyncrasies. To some extent the tracker can reduce errors by adjusting the frequency(200-500MHz). However, it is the licensing authorities that normally determine which frequencies are available.

Since 1986 biologists at the Wildlife Institute of India(WII) have equipped elephants, lions, Snow leopard, deer, otters and bats in different protected areas with various radio collars. A transmitter can do more than just gather simple information on the animal's location; it enables the tracker to predict where his animal is, where it may go next, and hence how best to stalk or ambush it for observations. In 1977 Pierre Charles Dominique from Brunoy, near Paris, described a comparably ingenious modification of an externally mounted transmitter. He was studying a small nocturnal animal, Allen's bushbaby (*Galago senegalensis*) in the tropical forests of west Africa. Each bushbaby was equipped with a waistband from which hung a transmitter. To the rear of the transmitter protruded a lip in which lay the exposed ends of two wires connected to the transmitter circuitry. When the bushbaby urinated, drops of fluid shorted the wires, allowing current to shunt through a lower resistance loop so that the transmitter pulsed at a different rate until the urine evaporated. The transmitters were delicately fashioned to accommodate the anatomical differences between male and female bushbabies. Charles Dominique was thus able to study urine marking in both sexes. In this way, while plotting the animal's movements, he could also discover that urine marking was most frequent at the perimeter of bushbabies' territories.

Signal changes have shown their potential in other equally diverse contexts. T.R. Loughlin of the National Marine Fisheries Service, Washington D.C., had fitted 164-MHz transmitters on sea otters (*Enhydra lutris*). Initially, Loughlin was puzzled that on one hand sea otters were reputed to feed only in the late afternoon, while on the other they have a high metabolic rate, eat upto 25% of their body weight each day and yet develop little subcutaneous fat. How could they tolerate fasting by night? Radio tracking solved the puzzle.

Sea otters spend much of their time floating in beds of kelp close to the shore. They gather shellfish from among the kelp or from the rocks down to 20 metres. By watching radio collared animals by day, Loughlin realised that because VHF signals were greatly attenuated in sea water, he could identify from the signal alone, three types of behaviour. The categories of behaviour were resting, active but not feeding, and foraging. By recording these categories at night, Loughlin found that this was when sea otters did about 45% of their feeding.

Biotelemetering features of the environment can complement information transmitted simultaneously from the animal, as Robert Kenwood of the Institute of Terrestrial Ecology has shown by his work on grey squirrels. Kenwood fitted a temperature sensitive device to the squirrel and put another in its drey. When the animal went into its drey the temperature around the thermistor rose, so Kenwood was able to tell when the animal was in its nest.

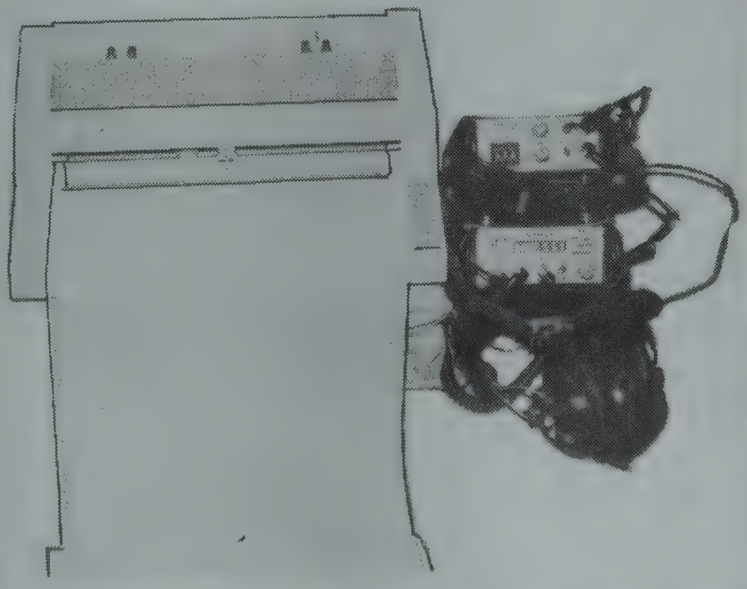
Radio transmitters have also yielded some insight into predator

prey relations. The first mortality transmitter was reported by Dave Mech from US Forest and Wildlife Service in Minnesota as early as 1967. In this case the pulse rate changed when a snow-shoe hare was killed by a fox and its temperature dropped. Mech also discovered that wolves and their prey, white tailed deer *(Odocoilus virginianus)* were partitioning the woodlands of Minnesota. During the winter months the prey gathered in aggregations at so called deer yards. Radio tracking of deer and wolf revealed that these deer yards were slotted into the boundary zones between the adjacent territories of wolf packs.

In a similar study of radio collared ungulates at the Sariska Tiger Reserve by the author a clear partitioning in habitat use was observed for the three radio-collared ungulates namely *nilgai (Boselaphus tragocamelus), chital (Axis axis)* and sambar *(Cervus unicolor)*. One more interesting finding was that even their food niches did not overlap much. Sambar preferred hills, whereas chital preferred a dense area normally a woodland. Nilgai preferred open scrub land. Such findings help in proper management of the reserve which benefit these ungulates. A belief that radiocollars fitted on the nape of big cats like lion and tiger interfered in their reproductive behaviour was also disproved. In a study in Chitwan National Park in Nepal, tigers mated freely and even cubs were born by the radiocollared tigers. A similar observation was also seen in case of lion in Gir National Park in Gujarat.

In general, radio tracking should be viewed as a way of minimizing a biologist's intrusion on his subject's life. And a radio transmitter that is so cumbersome and awkward that it interferes with its bearer's behaviour is not only to be deplored as inhumane, but dismissed as useless for sensible scientific purposes.

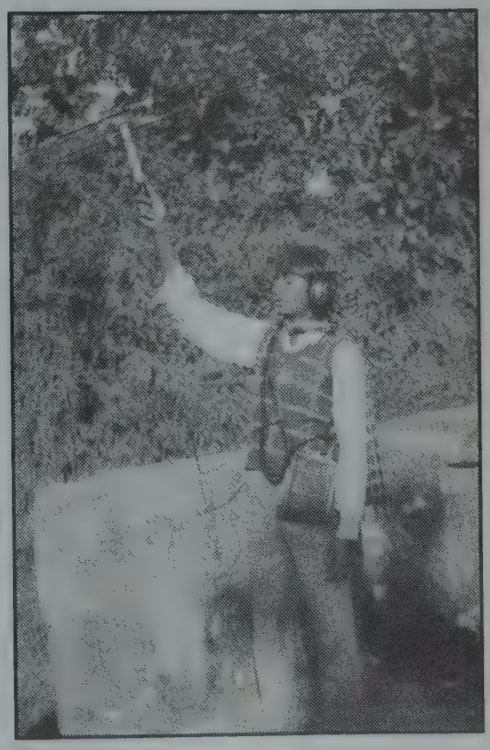
In early days of biotelemetry research workers tried to minimize the influence of the transmitters by reducing their size and weight conventionally to less than 5 per cent of the animal's body weight. Now-a-days transmitters are so small that they can even be implanted inside the animal. It is at least arguable that this is more humane; where once the animal might have been confined to a small cage and adorned with trailing wires, it may now be subjected to only a minor operation, and then released. Objectively too, such operations seem to do little harm. In one study conducted by biologists of WII at National Chambal Sanctuary, they implanted a transmitter into the peritoneal cavity (abdomen) of the Smooth Indian Otter. Till now they have not found any deleterious effect. In addition, implanted transmitters are often necessary to study the physiology of animals in that field; indeed such studies are now breaking down artificial barriers between physiology and ecology.



A tracker (right) gets a bearing of animal using a directional antenna. The data gathered is analysed by sophisticated equipments.

All in all, there is an appealing irony in radiotracking and biotelemetry; a high technology that might at first have seemed antipathetic to traditional field craft is helping today's biologists to realise the dreams of generations of naturalists to study wild animals more closely than ever before. With their keen senses and swiftness our subjects still have an edge on us, but radio tracking and biotelemetry are levelling the odds.

Radio tracking has advanced to such a stage, that an animal's movement and activity could just be monitored at home without even directly following the animal. This is made possible by satellite telemetry. The operation is quite similar to broadcasting radio programmes. A recent achievement in India was that of fitting radio transmitters on Siberian Cranes at Bharatpur. This was done to follow these migratory birds enroute to Siberia, which would enable scientists to know the cause of the decrease in number of cranes visiting Bharatpur



every year. Without satellites it wouldn't have been possible to overcome all geographical barriers.

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Breast Cancer

SURESH NADKARNI

BREAST cancer is amongst the commonest cancers in women. In Indians, the incidence of cancer of the breast, it is said is around 19.7 per 100,000. Nearly half of breast cancers are first noticed by the woman herself. Many a times, a bit too late. A woman, whose sister and mother had breast cancer, should get checked periodically for the disease. So should a woman with an illness of chronic cystic mastitis infection in breasts or with any nodules in breasts. A woman above the age of 40 also needs to be on the lookout for cancer. Bloody discharge from the nipple is a warning sign, so could be a retracted nipple. When facing such situations one would like to make sure about the presence or absence of the disease. Mammography is the answer. Mammography is an X-ray technique, which is used for imaging the breast. It helps the doctor to diagnose the benign or malignant cancers of the breast.

The medical approach to managing any disease involves a combination of prevention, diagnosis and therapy. This applies equally well to breast cancers. To prevent a disease, the cause must first be understood. Unfortunately the cause of breast cancer is not very wellknown, so that primary prevention is not possible.

In spite of improvements in therapeutic methods, there has been little change in the number of women dying from breast cancer. The experience shows that, the more extensive the tumour is at the time of treatment, worse is the outcome. Thus, the only promising approach to reduce the deaths from breast cancer is to diagnose and treat it early. Mammography is the only method to date which has convincingly demonstrated the ability to detect breast cancer at an early stage.

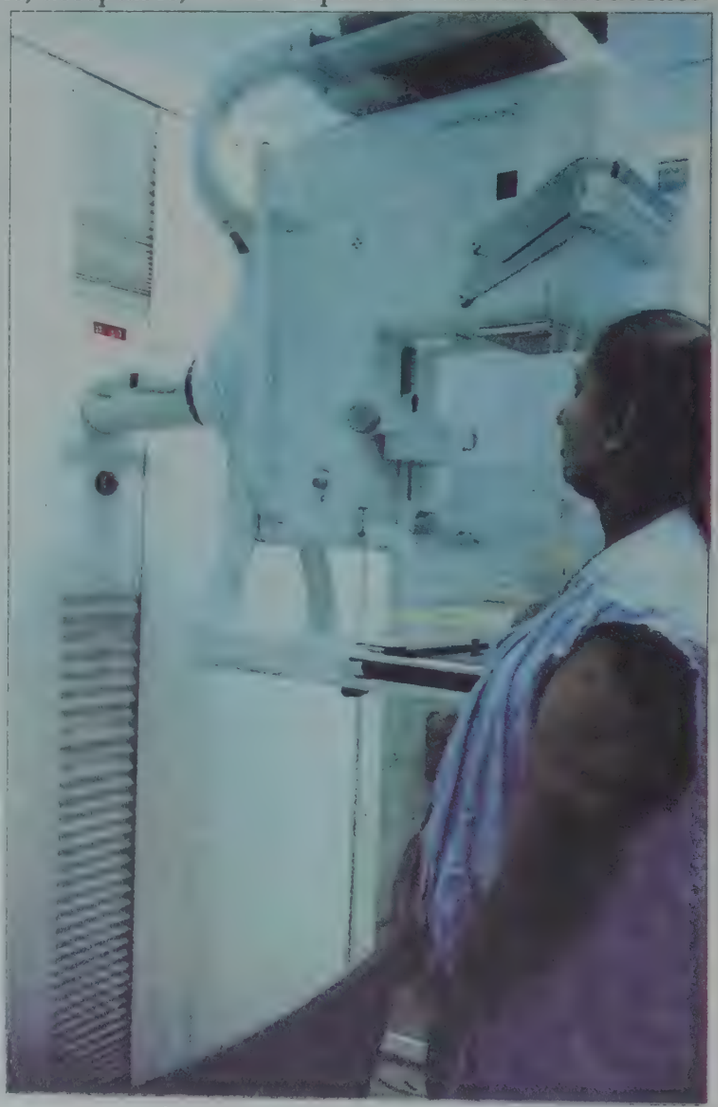
The technique of breast radiography (or mammograpphy as it is popularly known) was first described by Leborgne in 1953.

Since then the technique has improved quite a bit. Now it is not only accurate but involves very little of radiation risk.

Mammography is relatively easy to perform. It is simple, acceptable, reproducible, cheaper and has a low risk for the benefits offered. There are three radiographic methods available — firm mammography and Xeromammo-graphy.

Mammography is a special type of radiography, dealing with essentially two types of soft tissues : the muscle, glands, fibrous tissue, blood vessels which are full of water and the fat tissue. These show exceedingly poor contrast under X-rays. Hence there is need to enhance the radiographic contrast between fat and tissue of water density. This is usually achieved by using low energy X-rays, minimum filtration, small focus tube and a special single-emulsion filter with a single screen. The radiographic contrast is better at the lower energy setting. It may not be possible to set the machines at low Kv (e.g. 20 to 30 Kv) as it may impose a heavy load on the conventional X-ray tube and shorten its useful life. But, these days special tubes are available which permit operation at low Kv. In 1966 a new type of radiographic tube was converted in France by J.R. Bens and J.C. Delarve.

Over the years various departures from the classical principles of soft tissue radiography have occurred. The first departure was the introduction



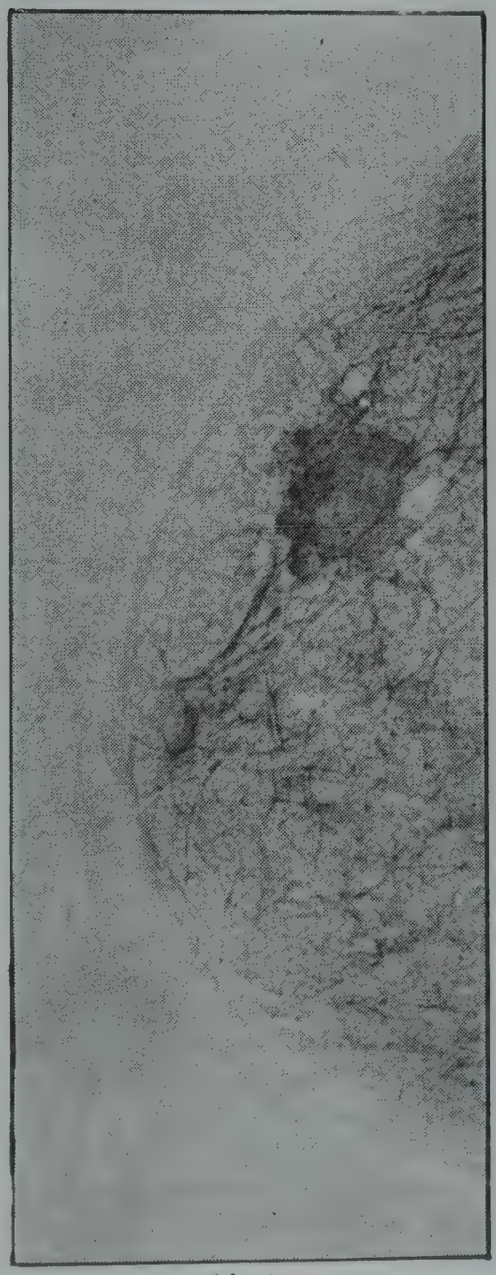
A woman undergoing mammography

of a film-screen combination. A single-grain intensifying screen is used as a backscreen in conjunction with a suitable film. The film sensitive to the light emitted by screen forms a latent image. These film screen combinations are used in the surveys of large number of breast cancer. Automatic processing has replaced the hand-processing of films. This is more convenient and faster, especially in mass screening projects. Specially developed grids have now been introduced for mammography. They can be stationary or moving grids. These grids allow better visualisation of breast structures, masses and microcalcifications (hard tissues).

Normal breast as seen in a mammograph

Another radiographic method of increasing contrast is the magnification technique. Where the significance of a small group of microcalcifications or a small mass lesion is in doubt, magnification tecnhique is helpful. It will show up the numerous calcifications and also the margins of the small mass lesions more clearly. However, its application is limited because a patient recieves more X-ray than during the other techniques which is not desirable.

In 1937, C.F. Carlson invented Xerography. The Xerographic principle depends on the fact that semiconductors such as selenium which ordinarily behave as insulators become conductors when struck by light or X-rays. Basically a charged selenium plate is discharged by X-radiation. The discharging is in proportion to the amount of radiation reaching the plate. This gives rise to an invisible electrostatic image on the plate, which is then visualised or developed by the use of electrostatically charged blue powder (a toner). The visible image so produced is then transferred and fixed on to the paper.



Breast with a tumour

Xerography has the following advantages over film radiography. It gives finer details, magnification effect, can be processed fast, needs no solutions, exposes the patient to low level of X-ray exposure and one can obtain positive or negative image.

One criticism against frequent use of mammography is that it could be harmful. The patient will be exposed to X-rays. However, the dosage of X-rays received varies considerably from one mammographic technique to another. There must be a compromise between dose reduction and acceptability of image quality. Other factors are the breast thickness and the kind of mammographic apparatus in use.

The standard procedure is to obtain at least two images of each breast. The modern mammography units are designed to operate with the patient in sitting or standing position. Attention to the details of radiographic technique is important in mammography as collimation of the beam, good patient positioning and compression of the breast.

Compression of the breast is achieved by a compression device of varying size and shape. It is necessary to bring the breast closer to the film to prevent blurring of images due to movement, for shorter exposure times. Compression also reduces the radiation dose since the thickness of breast tissue to be penetrated is lesser. It also allows to see clearly lesions at various depths in the breast tissue.

With a good mammograph the structure of breast can be visualised from all angles, which is important for proper diagnosis.

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Raiders On Papery Wings

KOLLEGALA SHARMA

JULY 5, 1993. Fifty batches of airborne enemies landed inside the borders of our country. It proved that the geographer's favourite description of our land as a sub-continent protected on all four sides by natural barriers was, after all, not true for every invader. Nor for them was the hot desert a barrier, nor the deep and vast oceans could stop them. For, the raiders were of a different kind, of the insect variety. On that day, 50 swarms of fully mature locust insects entered our country starting a war. The war was still on when this piece was on its way to the press.

War, indeed! For the desert locusts, or *Schistocerca gregaria* as the entomologists call them, are quite formidable enemies when they are in large swarms. They may not kill or maim humans, but left unchecked can starve them into despair. Each swarm, also aptly called as locust plague, contains not a hundred or two hundred insects, but millions and millions. There have been past records of locust plagues which descended, literally, from the sky as large clouds containing some 10,000 million locusts.

It is not just the astronomical number of locusts in a swarm that makes it a formidable enemy, but their appetite. The locusts in a swarm are also voracious eaters. They devour whatever greenery is in sight and can strip even a forest into a bare wood. Standing crops of a farmer are a poor match against such a threat. Hence the war-cry and the battle. The present swarm of locusts had spread in about 1 lakh square kilometres within a week of its arrival in India. To tackle such a huge problem, the Government of India had to employ five planes and a helicopter for spraying insecticides. According to reports, about 50,000 litres of the deadly insecticide malathion were set aside only to counter this invasion by insects. Fighting locust-plague is not cheap either. The cost of spraying insecticide over such a vast area came to Rs. 5 to 6 lakhs every day.

Desert locusts, otherwise are quite timid grasshoppers. They usually live solitary life feeding on desert shrubs and succulent plants. But as swarms, they are a different lot altogether. When in swarms, they breed profusely, are more aggressive, voracious eaters and are of entirely different colours. The life-history of desert locusts is a strange story, indeed.

The swarm which is sweeping the western border of India came from the north African desert, many thousand kilometres away. Infact, such locust swarms are not new to Indian farmers. There was one in 1988, too. It is the unexpectedness of the plague and its extent that are the cause of worry. Although such plagues recur, they do so not in regular intervals. Besides the number of locusts in a swarm is not the same in all the plagues. The migratory behaviour of locusts, thus, differs from the behaviour of other migratory animals like birds, fishes and butterflies and are quite unpredictable. The Indian government therefore, has set up a Locust Warning and Control Organization to keep a constant watch over any locust invasion, just as the Border Security Force is there to keep vigilance over human raids. Yet, sometimes the locust plague can defy the preparedness of farmers.

What makes the solitary insects turn into a huge migratory swarm? There is no definite answer, yet, to this question. However, biologists believe that the solitary grasshoppers turn into crowded swarms when there is overcrowding. Overcrowding results in over-breeding. It is said that the scents (pheromones) given off by neighbours in a crowded population rises to such unacceptable limits that it excites locusts to breed wildly, and set out on a journey. Indeed, when the eggs are raised under overcrowded conditions they develop into an altogether different adult, one with wings and a darker colouration. Usually grasshopper eggs hatch out and mature into weak winged adults which only hop long distances. The locust that is now raiding India is a dark yellow insect. The same locust when leading solitary life in the north African deserts is green in colour.

Locusts emigrate. That is, once out on a journey, they do not return to the place of their origin. Locust swarms travel at a height of several kilometres

above the ground and at a speed of about 10 km per hour. They descend at intervals during the journey to feed. They normally fly by day and can cover several thousands of kilometres in a month. In fact, the reports of a possible swarm were in the air long before the July 5, 1993 invasion. For,

major locust swarms had been seen in Saudi Arabia, Yemen and Somalia and some locust activities had also been observed in Oman and Pakistan in May itself. The Food and Agricultural Organization had sent out a warning, too. But it is not easy to say where a locust swarm is heading or where it would end.

Locust swarms actually fly as the wind flies. They migrate to regions where the atmospheric pressure is lower. In other words they head along the wind into those areas where there is a probability of rain. This is the reason why most locust swarms invading India come in the wake of monsoons. The only thing known about migrating locust swarms is that they would end whenever the swarms encounter wet conditions. No wonder, large swarms appear in India as soon as monsoon had ended.

The migrating swarms descend to ground as soon as they encounter wet conditions, feed voraciously and lay eggs in the wet-soil. It is therefore necessary to eliminate swarms which have landed before they get time to breed. The eggs buried under the soil hatch out in about a month and give rise to wingless adults which stalk the deserts denuding any vegetation that they encounter. Left unchecked, these could develop into another swarm. Sometimes, wasps which feed on the eggs of locusts accompany the swarms forming another nuisance after the swarm has passed.

Traditionally farmers have been fighting locusts by burying the wingless adults in sand. However, the introduction of pesticides has made fighting locusts easier. Yet, one can not be complacent. Each swarm that descends splits into several swarmlets and spreads out before landing. The first 50 swarms which came into the country on July 5, 1993 broke up into 150 swarmlets before landing and spread out. Therefore, strict vigilance only can prevent any swarmlet from escaping detection and causing a subsequent swarm. In fact, the second week of August saw a fresh swarm — the second wave — developing from the just hatched eggs. Latest reports say that even the second wave of the swarm has been under control by pesticide application.

The raiders on the papery wings may be tiny in size but the damage they cause to the crops is not small. Thwarting a locust plague with pesticides is no doubt the only option left, but is definitely not without dangers. For, the enormous amount of pesticide used to control the huge swarms may linger in the soil polluting it and also sometimes the water, thus upsetting the delicate balance of the desert ecosystem. □

COTTON THAT KILLS

SOUMANA DATTA

THEY have done it again. Another major breakthrough in plant biotechnology is very much round the corner. The scientists at the US multinational Monsanto Company, St. Louis, Australian company Cotton seed Distributors and the Council of Scientific and Industrial Research Organisation CSIRO of Australia have put in their heads together to bring out a species of cotton — genetically engineered and which has an inbuilt capacity to kill its predactors - specially the bollworm, *Heliothis* sp. a lepidopteran insect. And the "killer gene" is being provided by the bacterium

Bacillus thuringiensis (BT). The gene is so potent that the leaves of the genetically engineered cotton plant is able to produce a lethal toxin which kills the bollworm within 24 hours of feeding on it.

For the Monsanto Co. it is not the first time that they have come up with such a lethal weapon against the insects. Earlier, the Monsanto scientists had inserted the BT toxin genes in *Pseudomonas fluorescens* — a bacterium which lives on the roots of corn plants. When the cutworm, *Agrotis segetum*, another moth-pest, attacks the roots it unknowingly also ingests the 'toxic' bacteria and dies. A very elegant way of withstanding cutworm attack, wouldn't you say ? This successful "engineering" gave the idea of cloning and expressing the toxin producing gene in those bacterial like BT, where natural habitat is the leaf surface. Thus, lots of insect pests which feed on leaves can be killed in a very natural way.

IS the bollworm such a pest ? Well, yes. It damages flower buds, flowers and bolls, thereby reducing yield. In Sudan, massive losses are incurred in cotton yield due to *Heliothis armigera*. In Australia the bollworm is the worst crop-pest, attacking cotton, corn and even soybean. It causes an annual loss of a staggering 250 million dollars to the Australian rural industry. Even in India, the collton crop is under attack by many insects, thus causing worry to the plant scientists. The general method of control of these pests is by the use of potent synthetic pyrethroids. Their extended use has resulted in resistance in bollworms. Also, the use of chemical insecticides has resulted in secondary pest outbreaks. The answer, therefore, is the use of biopesticides which are cost effective, can be safely stored and are target specific. This is where the toxin produced by BT comes to the rescue of man.

Bacillus thuringiensis gets its name from the Thuringen province in Germany from where it was first discovered. It caused a fatal septicemia in the larvae of the flour-moth. In late 1930s, BT was being widely used as a biological insecticide to control the Japanese beetle. A protein, delta endotoxin which is formed during bacterial sporulation causes this insecticidal activity. Majority of BT acts against moth insects but BT var. *Israelensis* (BTI) acts on mosquitoes and flies (dipterans) BT var. *tenebrionis* and BT var. *San Diego* are effective against beetles (coleopterans).

It is BTI which is a source of great joy and optimism to the Malaria Scientists of the world. With BTI formulations we may see the end of the mosquitoes - the pest that spreads malaria. Already various companies have started producing BTI formulations. BT Var. *Kurstaki* based bioinsecticides were introduced in the 1950s in the United States under the trade names Dipel, Parasporin, Agritol, Thuricide, Larvatol, but it is French who were the first to commercially produce Sporeine in 1938. Presently more than 500 insects belonging to various orders are reported susceptible to BT. It is estimated that currently 95% of the commercialised biopesticides are based on BT and in 1985, the Western market of BT-based biopesticides was reported to be near 45 million dollars and gloablly estimated at 60 million dollars which rose to 100 million dollars in 1900 !

IN the 1980s, scientists had isolated and analysed the gene from BT and studied its insecticidal properties. One group even integrated the delta-endotoxin gene of BT var *Kurstaki* HD-1(BTK) into the chromosome of the bacteria *Pseudomonas fluorescens* and *Agrobacterium radiobacter* which colonize plant roots. When this BTK gene was introduced into tomato cells, the transgenic plants produced the insect-control protein in such levels that it could kill 3 important tomato pests. Yet another group put it into a tobacco plant. The transgenic plants produce the toxin in plant leaves which kills the feeding hornworm, *Manduca sexta*. The American and Australian scientists have been successful in their latest venture of producing "killer" cotton.

Has nature made cotton so weak? Is there no natural defence system present in cotton which can deter such predators ? In fact, there is. A poisonous alkaloid, Gossypol, naturally found in cotton plants renders the plant unpalatable to feeding insects. There is even an unknown factor in the yellow pollen which is harmful larvae of *Heliothis* spp. and other moths. But the effect of this alkaloid is only marginal. Therefore the need of biopesticides like Elcar. which kills *Heliothissp.* But biopestcides are also not a very reliable solution to the problem of controlling pests. They are costly and are invariably washed off by irrigation or rain water. Also their narrow range of host specificity and the requirement that the spores should get inside the body of the target species to kill it are drawbacks which have forced scientists to look for other alternative approaches to control pests.

In such circumstances, genetically engineered plants like 'killer cotton' can play a major role in integrated pest management strategies. In this case, the 'killer' is a beauty. Not only is the toxin activated in the gut of the ballworm, it also does not harm humans, other mammals or even spiders. That is, it is environment friendly. With "killer" species, cotton farming will bring the smile back to the farmers' faces. And also a bulge in their pockets !!

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ATOMIC WORLD, TIME SHIP, THE LAND OF THE LAWS, and **ENERGY TOWN** *by* R.S. Bhoosnoormath, *Navakarnataka Publications (P) Ltd*, Embassy Centre, Cresent Road, P. Box 5159, Bangalore 560 001 Pp 32 (each) Rs 7.00 (each)

THE attractive and colourful covers catch one's attention immediately but the text lets one down. Although it is clear that the author intended to simplify concepts of science for children, the attempt seems half-hearted at most. Although *Time Ship* has a story line that explains the steps leading to the evolution of modern man, it could not rise above

being a mere science fantasy in which the twins Papu and Baby (not to forget their pup, Puppy!) merely hunt impossible bird dinosaurs and exchange gifts with cavemen. The *Atomic World* is slightly better structured. It is a tale in which the twins are carried to the inside of an atom by a typhoon, where they meet and make friends with neutrons, electrons and protons. In the process they learn the rudiments of atomic structure and the behaviour of molecules. *Energy Town* has a brilliant theme but falls flat for lack of imaginative execution. Papu and Baby visit Energy Town on a runaway tonga drawn by a talkative horse (horse power at its bestq!) *The Land of the Laws* is a pure fantasy land where topsy-turviness is the order of the day.

Considering that the books have been designed for children and look attractive it is unfortunate that the language has been carelessly handled. The books are also priced low. But just keeping the price low cannot be the sole criterion for children's books. These books demand and merit standardized proof reading and strict editing. The text must be crisp and correct. Only then can the efforts of the author and the publisher justified. Only then is a good children's book created.

Sukanya Datta

STEPHEN HAWKING - A Life In Science *by* Michael White and John Gribbin, *Penguin Books* (Available with: *Penguin Books India (Pvt) Ltd.*, B-4/246, Safdarjung Enclave, New Delhi-110029), Pp. 304, Rs 95.00

WITH his fame spreading far and wide, Stephen Hawking has become a legendary figure. His name is now known to millions around the world. His recognition in the scientific community is understandable, but how is it that he is popular among the common masses, too ? This may in part be attributed to his popular book *A Brief History of Time* which became a bestseller in 1988. However, Stephen Hawking is much more than just a popular science writer. He has made fundamental breakthroughs in cosmology. His theoretical work on black holes and his revolutionary concepts about the nature and origin of the universe have proved to be of fundamental importance. Although he is suffering from ALS, a wasting neurological disease, also called "motor neuron disease", and has to remain confined to his wheelchair for most of his life, he never allows his illness to come in the way of his scientific pursuits. Despite his disabilities he is very much a lively person with the same desires, drives, dreams and ambitions as any able-bodied person. He has been variously proclaimed as `Einstein`s heir', `the great genius of the late twentieth century', `the finest mind alive and as the `Master of the Universe'. Such is the charisma of Stephen Hawking's personality. There is indeed a lot to learn from his work as well as his life. An attempt has therefore been made in the book

under review to peep into the life of the great genius. It is both rewarding and inspiring.

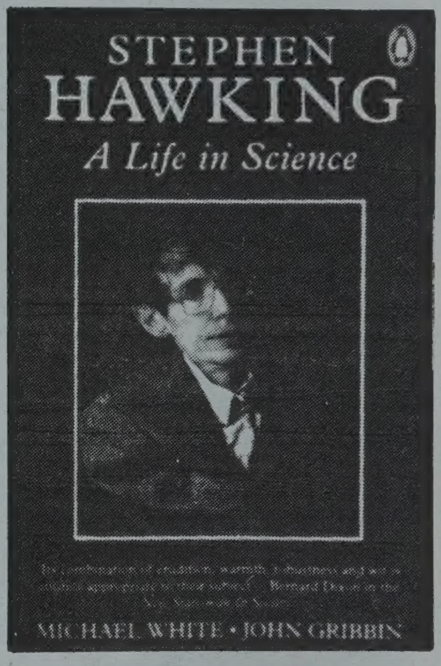
The opening pages of the book describe an interesting encounter of Hawking with a famous Hollywood actress, Shirley Maclaine, in a Cambridge restaurant. The two celebrities discuss on various issues including metaphysical and religious matters. The charming actress is simply shocked to note that Hawking does not believe in the existence of God! In fact, as spelt out by Hawking in *A Brief History of Time*, he found strong support for this belief in his cosmological studies. Wrote Hawking, "So Long as the universe had a beginning, we would suppose it had a creator. But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end ...."

Hawking's career started in 1962 when after getting undergraduate honours degree from Oxford he joined Cambridge University to do PhD. in cosmology. Although he wanted Fred Hoyle to be supervisor, he was placed under the charge of one Dennis Sciama. Soon, he discovered that Sciama was a fine scientist and a helpful and stimulating supervisor too. In due course, the devastating symptoms of ALSY started manifesting in him. Hawking was shocked and depressed and thought that there was nothing to live for. But, slowly, he reconciled with the situation and accepted his plight. Meanwhile his research progressed at a painfully slow pace.

Hawking along with the other members of the research group under Sciama used to attend talks and seminars at King's College in London. In one of the talks, Roger Penrose introduced the idea of a space-time singularlity at the centre of a black hole. That night after the talk, on his way back to Cambridge, in a second-class compartment, Hawking began to wonder what would happen if he applied Roger's singularity theory to the entire Universe! In fact, it was his application of the sigularity theory to the entire universe that won him his Ph.D Hawking was at that time twenty-three years old. Subsequently, he joined hands with Roger Penrose to work on the singularity theory. They came out with a startling conclusion that there must have been a singularity at the beginning of time. In a nutshell, the end result of their joint research was that the expansion of the Universe was the exact opposite of the collapse of matter into a black hole.

Meanwhile he married Jane Wilde whom he had first met in a party thrown by him on New Year's Eve and his physical condition had started deteriorating very fast. He was forced to abandon his crutches and take permanently to a wheel chair. His speech had become highly unintelligible. However, his interest in research continued unabated.

Hawking happened to come across the inflationary-universe theory put forth by Alan H. Guth. He became curious about the theory and began to work out the details himself. He finally came forth with chaotic-inflation theory which is a modification of the inflation theory propounded by Guth. Hawking's 'chaotic inflation' is a highly complex theory. Later he presented ideas concerning this theory in *'A Brief History of Time'* which took the world by storm. However, one of the major reasons for writing this popular science book, as the biography under review indicates, was Hawking's own deteriorating financial condition.



During the course of writing the book, Hawking suddenly suffered a blockage in his windpipe and had to undergo tracheostomy operation which resulted in total loss of speech. After the operation, a breathing device was implanted in his neck above the collar-level. Subsequently, Hawking had to remain content with a computer-generated voice synthesizer for communicating with the outside world. However, a Cambridge computer engineer, David Mason, successfully built a portable version of this device which could be attached to Hawking's wheel chair. His voice could now go with him. Encouraged, he started travelling abroad delivering lectures an attending seminars. In recognition of his ground-breaking work, many honours and awards were bestowed upon him. Besides, a documentary titled 'Master of the Universe' and a film on *'A Brief History of Time'* were also made.

All this is written lucidly in the brilliant biography under review. Besides bringing forth the sensitive, humorous and tenacious side of Hawking's personality the authors have also been

able to explain in a down-to-earth manner some of the complex ideas of Hawking, particularly those relating to black holes and the expansion of the Universe. The book conveys successfully that scientific research is not just a dry intellectual pursuit but an adventure full of joy, despair and humour, and fraught with inter-personal problems and rivalries which mark all human endeavours. Certainly, a well-documented and immensely readable biography which should find place in the shelves of all libraries.

P. K. Mukherjee

WHY ARE THINGS THE WAY THEY ARE and **A HOT STORY** *by* G. Venkataraman, *Universities Press (India) Limited* 3-5-820 Hyderguda, Hyderabad 500029, Pp VIII + 112; Pp VIII + 134, Rs 35 and Rs 40.

PHYSICISTs are well known for quick estimates whether it is the energy released during an atom bomb explosion or it is the number of pianos in Chicago.]From the legendary table top calculations of the physicists of Gattingen as described in *'Brighter than a thousand suns'*, the tradition still continues as Stephen Hawking said recently, "When we want to save something we just photocopy the table". How do the physicists go about the business of estimating ? How does one argue, assume and put upper and lower limits to them ?

G. Venkataraman shares the fun of such calculations in the book *"Why are things the way they are"*. With the help of a few fundamental constants like gravitational constant G, electronic charge e, gas constant R, Planck`s constant h, Boltzmann constant KB the author shows how one can calculate such widely varying factors as the Bohr radius and the radius of a star. As he moves from solids and liquids to stars he takes readers through atomic physics, nuclear physics and elementary particle physics, and reveals the link between the infinitely small to the infinitely big. All the back-of-the-envolope calculations, as the author calls them, are well supported by relevant information in separate boxes and neatly drawn figures. To keep the interests of readers alive, theories and estimations are interspersed with several anecdotes and tit-bits of information. For instance, J.J. Thompon got Nobel Prize for discovering the `particle' electron while his son G.P. Thomson got Nobel Prize for proving that it was also a wave; Boltzmann who singlehandedly developed the kinetic theory of gases could not stand the criticism and hence kileld himself by jumping into the sea; Hetherington included his cat`s name as a co-author in a paper sent for publication to the *Physical Review Letters*.

To arouse curiosity in young minds and to make them think, the author puts a lot of questions and guides them to solve them using simple methods. To name a few : Why are elements with atomic numbers like, say, 856 not known ? As the nuclear charge increases electron orbits come closer to the nucleus and the velocity of circulation of electrons increases. As the velocity cannot exceed that of light, there cannot be a stable atomic structure with nuclear charges in excess of 137. Why mountains cannot grow infinitely high ? The weight of the mountain would cause the atomic and molecular bonds to break melting the underlying rock. The mountain as a whole would therefore start sinking. The maximum height of mountains would always be less than 30 kms.

A hot story is a more advanced physics book. Heat is defined as disordered energy and measurement of heat involves measurement of energy as well as measurement in disorderliness. the author takes readers through the laws of thermodynamics, statistical mechanics, quantum statistical mechanics and introduces the concepts of relaxation, H-theorem, time reversal symmetry and so on. He shows Dewar and Kammerlingh Onnes' attempts to liquify helium had the same spirit of competition and drama as seen during the elucidation of DNA structure by Pauling and Watson and Crick.

The readers are allowed a glimpse of the latest in physics as well. In addition to the Big Bang theory and the Hubble expansion, the "Big crunch" also gets a mention. The author`s admiration for the great physicists of yesteryears as well the present day, be it Fermi, Feynmann or Chandrashekhar and Stephen Hawking, is obvious as one goes through the two books. He is able to instill the same feelings for them in his readers as well. Ample reading references are given for the interested readers. Like Kipling wrote *If* for his son, Dr Venkataraman shares his interest in physics with all young minds in memory of his son. He wants his books to be regarded as a sort of `Junior Feynman series'. Without any doubt they are.

S. Sivakamasundari

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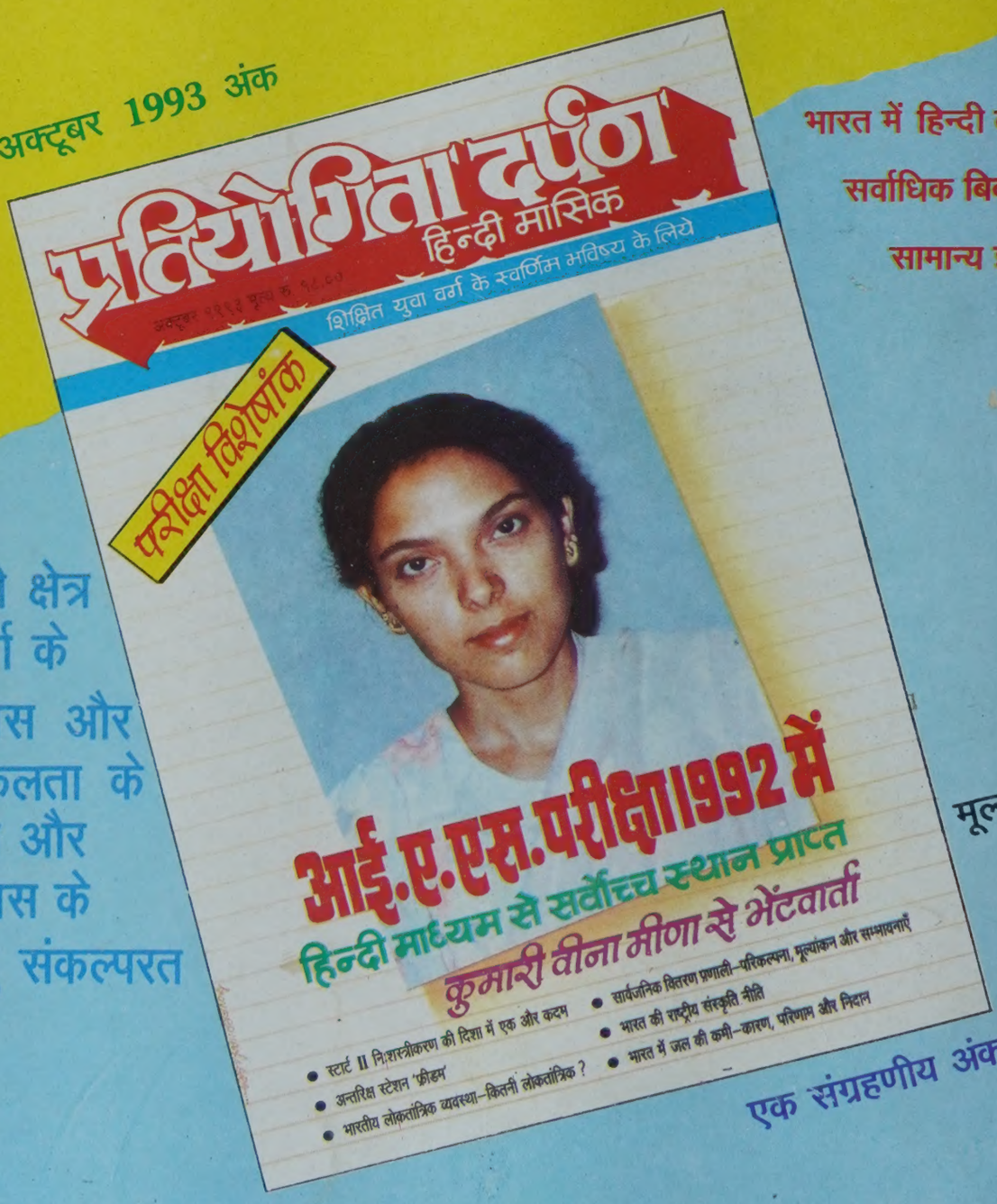

भारत में हिन्दी की
सर्वाधिक बिकने वाली
सामान्य ज्ञान पत्रिका

हिन्दी भाषी क्षेत्र के युवा वर्ग के समग्र विकास और उनमें सफलता के प्रति आशा और आत्मविश्वास के संचार हेतु संकल्परत

मूल्य - 18/-

एक संग्रहणीय अंक

आज ही अपने निकटतम पुस्तक विक्रेता से खरीदें या पूरा मूल्य मनीऑर्डर द्वारा हमें भेजकर पत्रिका मँगाएं

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